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Environmental Levels of PCB in Great Lakes Fish

Minnesota Univ., Minneapolis. School of Public Health

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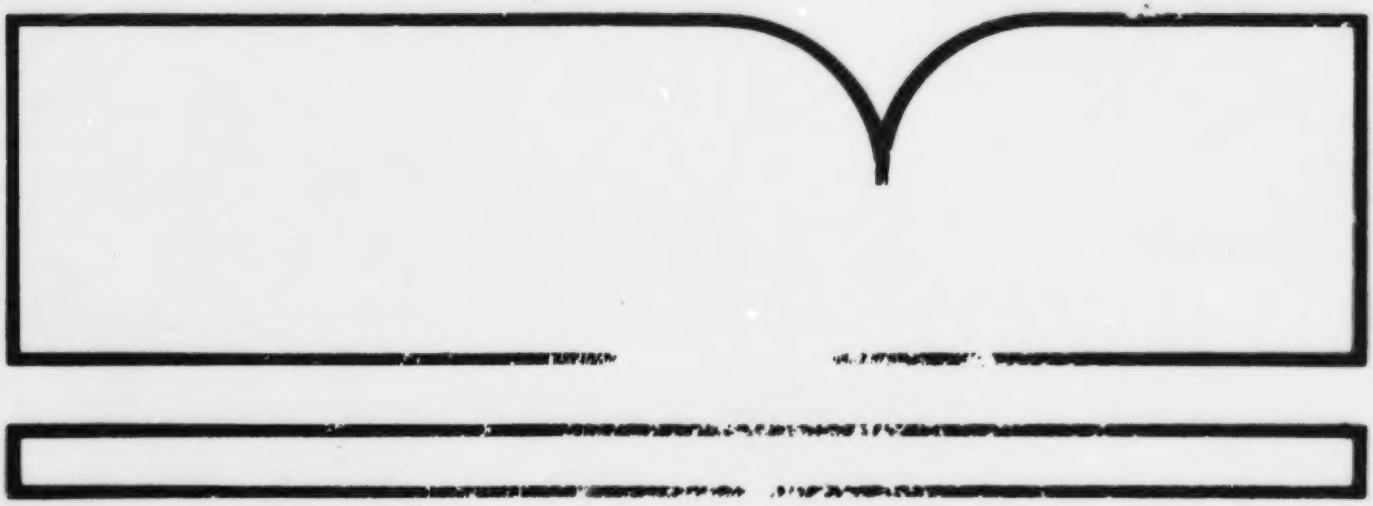

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September 1983

ENVIRONMENTAL LEVELS OF PCB IN GREAT LAKES FISH

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and
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16. ABSTRACT

This report reviews and evaluates previously reported PCB levels in a variety of fish sampled from various locations in the Great Lakes. Higher concentrations in fish appear to be related to near-shore sampling where higher exposure to bottom sediments occurs to the flora and fauna comprising the food chains for the specific fish collected. Highest concentrations of PCBs were found in lake trout and fat trout taken from Lake Superior and in fish collected from the lower end of Lake Michigan. There is a need to identify past and/or present sources contributing PCB contaminants to the off-shore areas as well as to identify major sources of runoff contributing PCBs to the waters of the Great Lakes system. Additional information as to food-chain constituents is needed to more readily assess prey-predator relationships in the various regions of the system.

Fish taken from some of the sampling areas exceeded the FDA limit of 5 mg PCB per kg of fish; if the level is lowered to 2 mg/kg many more fish will exceed the proposed limit.

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Abstract

This report reviews and evaluates previously reported PCB levels in a variety of fish sampled from various locations in the Great Lakes. Higher concentrations in fish appear to be related to near-shore sampling where higher exposure to bottom sediments occurs to the flora and fauna comprising the food chains for the specific fish collected. Highest concentrations of PCBs were found in lake trout and fat trout taken from Lake Superior and in fish collected from the lower end of Lake Michigan. There is a need to identify past and/or present sources contributing PCB contaminants to the off-shore areas as well as to identify major sources of runoff contributing PCBs to the waters of the Great Lakes system. Additional information as to food-chain constituents is needed to more readily assess prey-predator relationships in the various regions of the system.

Fish taken from some of the sampling areas exceeded the FDA limit of 5 mg PCB per kg of fish; if the level is lowered to 2 mg/kg many more fish will exceed the proposed limit.

Environmental Levels of PCB in Great Lakes Fish

1.0. Introduction.

Human exposures to organic chemicals and potential health effects may be related to the intake of fish taken from the Great Lakes, since fish, which form a part of the diet, have shown the highest levels of contamination. Possible exposure through the ingestion of contaminated fish far exceeds the possibilities of exposure through inhalation of contaminated air or ingestion of contaminated waters. More data are available on levels of PCBs in the environment than on many other organic contaminants, therefore, PCBs may serve as the indicator organic chemical for potential human exposure.

The intent of this review is to identify, based on available data reported to us, the major species of fish contributing PCBs to the diet of man, and the major sources of contamination based upon the areas from which the fish were obtained. This information will be helpful in identifying the major sources of exposure to human populations both in terms of species consumed and areas from which the fish were obtained. Having identified the major species of fish, the area from which they were obtained, and, ultimately, their levels and areas of maximum consumption, it may be possible to relate consumption to possible health effects as noted from the complimentary epidemiological study underway.

This review will first identify levels of contamination in samples of lake trout in Great Lakes waters by sampling area, since this species was most extensively studied, and will then identify levels by location for other species of fish which form part of the human diet or may serve as food sources for fish at higher trophic levels. Our primary concern is for possibilities of human exposure, even though we fully recognize the importance of the total ecological systems approach, particularly with respect to predator-prey relationships. In

fact, the latter is necessary to fully understand and appreciate the potentials for human exposure through ingestion of fish. One other aspect that is not directly considered in this review is the potential for infant exposure through breast feeding by mothers exposed to PCBs in their diets and accumulations of these agents in fatty tissue.

2.0. Conclusions and Recommendations.

On the basis of the study completed, the following conclusions may be drawn based upon the data available to the authors and the assumptions referred to in the text.

1. There is a dearth of information on PCB levels in many species of fish collected from various locations. In many instances, only one or two samples were collected annually or biennially, therefore, it is difficult to estimate the significance of the PCB levels reported or changes therein.
2. Where more data were available for specific fish from given locations, it was possible to demonstrate that the PCB concentrations reported varied in a log-normal manner. This distribution presents some problems in terms of translating potential exposure levels to humans from the geometric mean values.
3. Based upon data reported for fish collected from certain areas of Lake Superior ~~(MS-3, MS-4, and MS-5)~~ the concentrations generally were lower, whereas near-shore samples included in these same areas showed higher concentrations. These higher values probably reflect higher bottom mud and sediment concentrations in the near-shore areas.
4. Little usable information is available on food-chain levels in the Great Lakes system. Such data are needed to help interpret differences in levels observed in fish taken from the various locations.
5. Insufficient data are available on those fish identified as being preferred from a human intake standpoint. Such information is necessary

to help estimate the role that these fish play in human diets and potential human exposure resulting therefrom.

6. At only a few sampling points were multiple fish species collected and where collected they were few in number.

These conclusions suggest the following recommendations:

1. All subsequent investigations of fish and other media in the Great Lakes should be coordinated through a central organization which can specify the kinds of fish to be collected, numbers of fish, and locations for sample collection.
2. There is a greater need for reporting, and this may be available in other material which did not accompany the data available to us, what portion of the fish was examined-whether the total fish, edible fraction, etc., to provide a better base for comparing samples. Similarily, methods used for analysis should be reported and a uniform system of of quality control should include all laboratories carrying out these studies. The specific standard used for estimating the PCB concentration should be indicated and information on the acutal isomers identified should be reported.
3. With the isolation of areas of higher fish contamination, a concerted effort should be made to indicate whether such contamination levels reflect current discharges of PCBs or sources that have accumulated over time.
4. Stomach contents of the fish caught should be examined to identify feeding habits in the various parts of the lake system during different seasons of the year.
5. The age of fish should be reported, inasmuch as length and weight may not always be indicative of the age of the fish and the time spent in a given location. This information would be helpful in comparing PCB

levels in fish taken annually.

6. The migratory patterns of fish through their life cycle should be identified even though fish stocking takes place from hatcheries, since hatchery fish probably migrate.

3.0. Sampling Areas and Species of Fish Sampled.

3.1. Sampling Areas.

Areas from which samples were collected carried two types of designations-some being identified by specific shore locations and others by specific areas in the Great Lakes. These sampling locations are indicated in Figs. 1 to 3, which, respectively, identify areas from which fish were collected in Lake Superior; Lakes Michigan, Huron, and St. Clair; and Lakes Erie and Ontario and the St. Lawrence River. The areas indicated in Lakes Superior, Michigan, and Huron were identified in reports from the State of Michigan,[1] the specific sampling points, namely: 1 to 11 on Lake Superior; 12 to 15 on Lake Michigan; 16 on Lake Huron; 17 on Lake St. Clair; 18, 19, and 24 on Lake Erie; 20 on the Genesee River; 21 and 22 on Lake Ontario; and 23 on the St. Lawrence River were identified in information retrieved from "STORET"[2-5] and from data reported by Koch.[6] Since some of the areas from which fish were sampled were quite extensive, the exact locations may vary for collections made at different times. The data used in this review were from the above reports.

3.2. Species of Fish Sampled.

The most extensive data available for study were on lake trout, but data in variable number were reported for fat trout, carp, catfish, yellow perch, whitefish, walleye, sucker, red sucker, black crappie, brown bullhead, herring, fresh water drum, bloater, burbot, brown trout, rainbow trout, muskie, salmon, chinook salmon, cisco, and smelt. Similar species were not sampled from all sites-probably due to the fact that all species were not found at all locations. The species of most interest are those that have been identified as major food

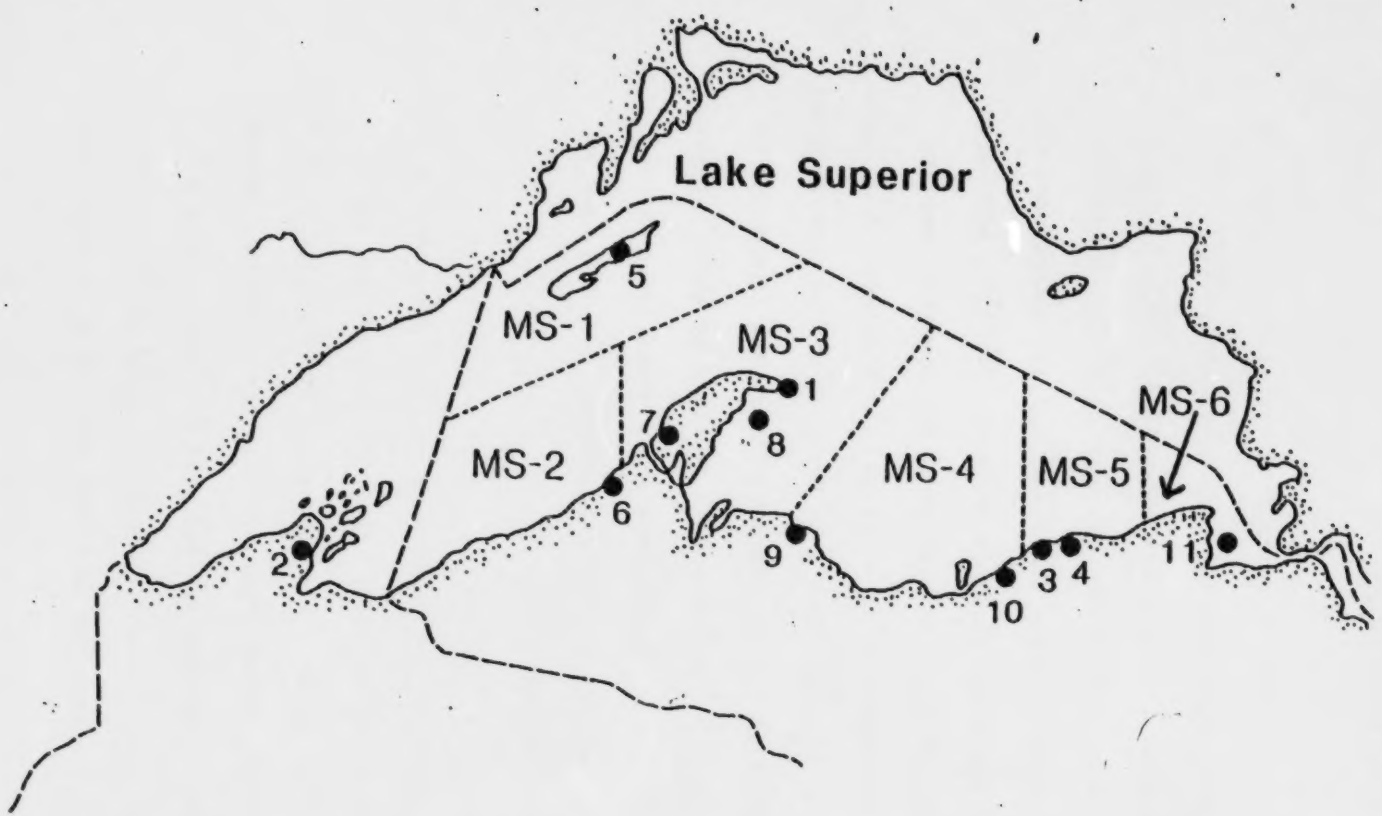


Fig. 1

1	Keweenaw Point (Michigan)	MS-3
2	Bayfield (Wisconsin)	
3	Au Sable Point (Michigan)	MS-5
4	Grand Marais (Michigan)	MS-5
5	Isle Royale (Michigan)	MS-1
6	Ontonagon (Michigan)	MS-3
7	Calumet (Michigan)	MS-3
8	Betsy Bay (Michigan)	MS-3
9	Marquette (Michigan)	MS-4
10	Grand Portal (Michigan)	MS-4
11	Whitefish Bay (Michigan)	MS-6

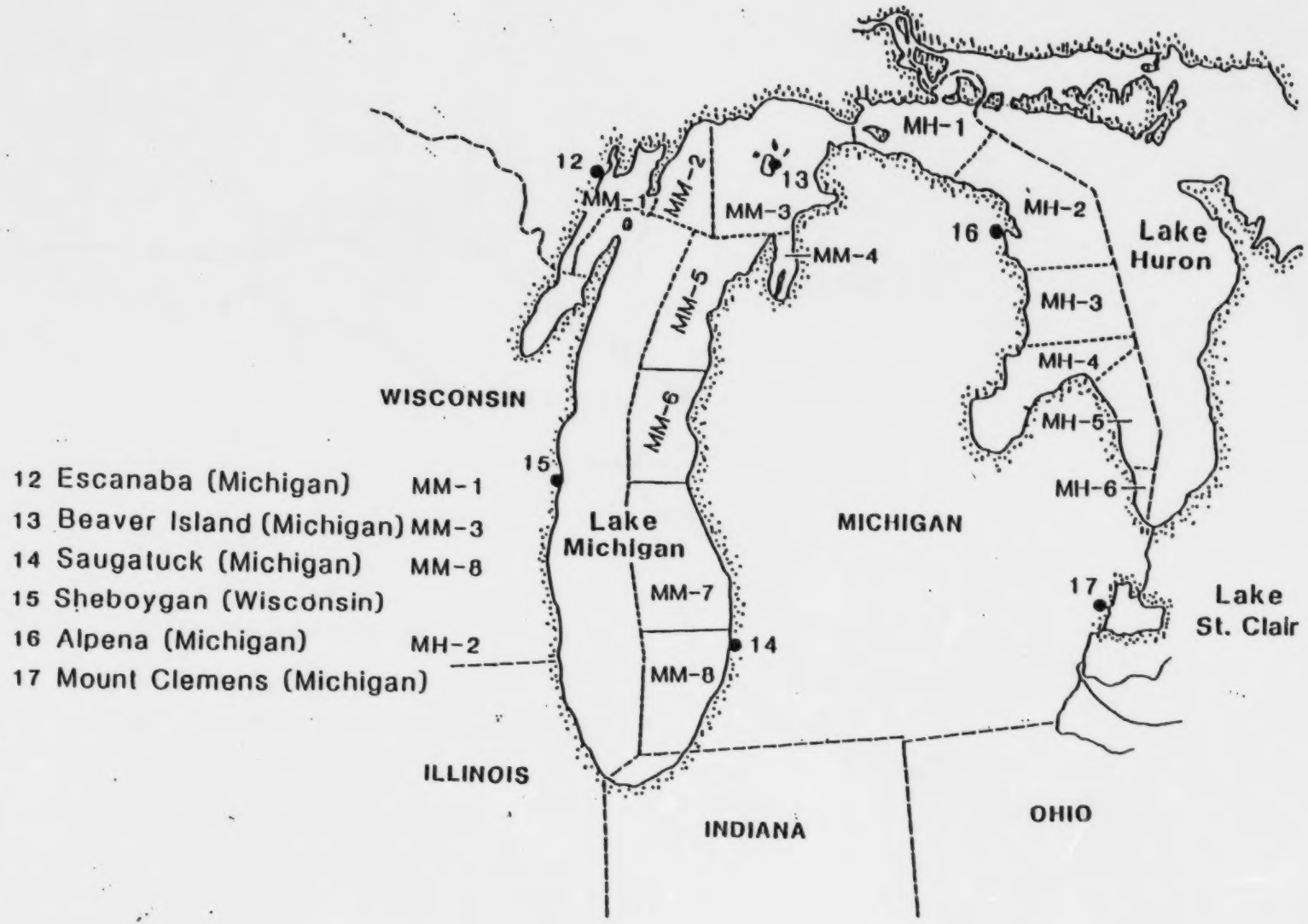

12 Escanaba (Michigan) MM-1
13 Beaver Island (Michigan) MM-3
14 Saugatuck (Michigan) MM-8
15 Sheboygan (Wisconsin)
16 Alpena (Michigan) MH-2
17 Mount Clemens (Michigan)
MH-1
MM-1
MM-2
MM-3
MM-4
MM-5
MM-6
MM-7
MM-8
MH-2
MH-3
MH-4
MH-5
MH-6
Lake Huron
Lake Michigan
Lake St. Clair
MICHIGAN
WISCONSIN
ILLINOIS
INDIANA
OHIO

Fig. 2

18 Port Clinton, Ohio
19 Erie, Pa.
20 Genesee River (Scottsville) N.Y.
21 Port Ontario, N.Y.
22 Cape Vincent , N.Y.
23 Massena, N.Y.
24 Monroe, Mich.
Lake Ontario
Lake Erie
N.Y.
PENN.
OHIO
18
19
20
21
22
23
24

Fig. 3

sources. These, in order of preference as indicated by preliminary data from the epidemiological questionnaire on ingestion habits of commercial fishermen, are yellow perch, lake whitefish, lake herring, and lake trout.

4.0. Results.

Only the data reported for PCB levels in fish are included in this review. Since specific information, with few exceptions, was not available on the portions of fish analyzed, the assumption was made that the data represented PCB levels in whole fish based upon the wet weight of the fish. Unfortunately, the ages of the fish sampled were not reported and the rate of growth from year to year was not available for the various species analyzed, making it impossible, where sufficient numbers of fish were sampled from year to year, to compare fish of the same age during different time periods. Because length and weight (wet) were reported for many of the fish data used, length-weight curves were plotted (see Appendix B, which shows length-weight relationships for lake trout in Lake Superior) to make it possible to report PCB concentration as a function of weight when length only was reported.

Since we are dealing with biological systems, the data were plotted in the form of semi-logarithmic plots of PCB concentration (log scale) vs. length (arithmetic scale) or weight (wet) (log scale) vs. length (arithmetic scale); as logarithmic plots of PCB concentration (log scale) vs. weight (wet) (log scale); and as logarithmic probability plots of PCB concentrations. In addition, fish body burden (mg) vs. fish weight (grams) was plotted on log-log paper and demonstrated a better linear relationship than that reported by others using an arithmetic plot.

No information was available in the data sources reviewed on the analytical procedures used for identification of the PCB levels found in fish. In most instances, no information was provided on the standard used for estimating the PCB levels found. Some data were available on the different Aroclors measured.

In these instances the values reported were for total PCB levels, i.e., the sum of the individually identified Aroclor PCB levels.

Since the most extensive data available for study were for lake trout, these data will be reviewed first.

4.1. Lake Trout.

The data reported and reviewed for lake trout are listed in Table A.1. (Appendix A) and plotted in Figs. 4 a-f. The values are plotted moving from west to east for Lake Superior and moving eastward with values reported for Lake Michigan and Lake Huron. The areas from which samples were collected are indicated in Figs. 1 and 2.

4.1.1. Lake Superior (Figs. 1 and 4 a-c).

Since, as indicated, we are dealing with biological systems, geometric or logarithmic interpretations of the data are valid, with median values being reported where sufficient samples were collected, because they are more closely related to geometric mean values than are arithmetic mean values. Use of median (approximate geometric mean values) are more difficult to identify with average mean values but they are more representative of the actual variations in levels observed representing substantial differences in many cases.

Samples collected at Bayfield, Wisconsin, in Lake Superior (Fig. 4a), only one or two each year, showed minor variations in PCB concentrations during the period 1969-1977 ranging in values from 1.3 to 2.8 mg/kg (wet weight).

More samples were collected from the Isle Royale area of Lake Superior (Fig. 4a), during each of two sampling periods in May, 1974 and May, 1975, with total numbers of 12 and 19 samples, respectively. An examination of PCB levels during each of these two periods as a function of fish size---<3 lb, 3 to 5 lb, and 5 to 10 lb, respectively, showed increased concentrations with size and increased concentrations during the second year of sample collection in each size increment, as indicated by the median values. Overall PCB concentrations

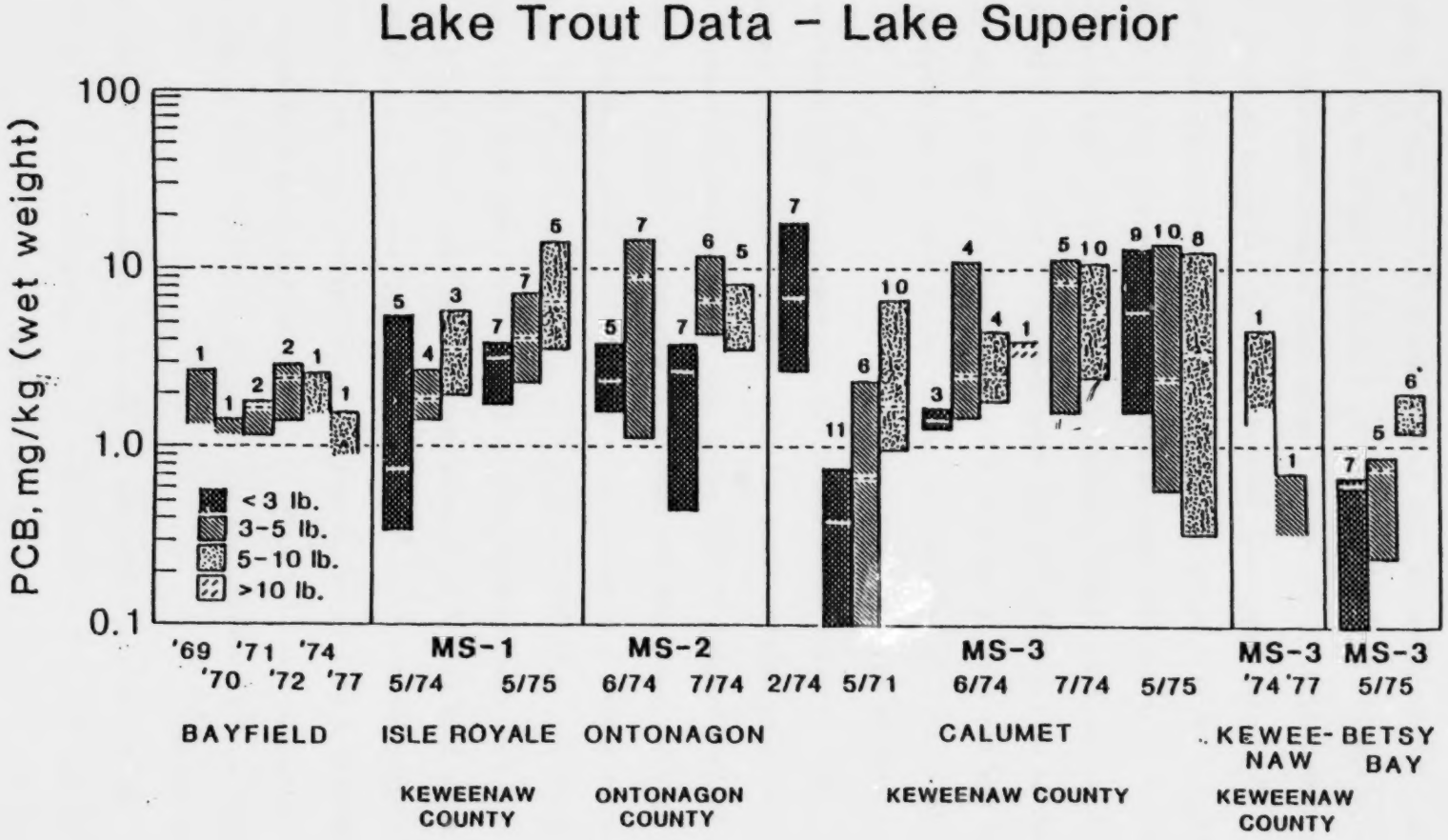

Lake Trout Data – Lake Superior
PCB, mg/kg (wet weight)
100
10
1.0
0.1
< 3 lb.
3-5 lb.
5-10 lb.
>10 lb.
'69 '71 '74
'70 '72 '77
MS-1
5/74 5/75
MS-2
6/74 7/74
2/74 5/71
MS-3
6/74 7/74 5/75
MS-3
'74 '77
MS-3
5/75
BAYFIELD
ISLE ROYALE
KEWEENAW COUNTY
ONTONAGON
ONTONAGON COUNTY
CALUMET
KEWEENAW COUNTY
KEWEE-NAW
KEWEENAW COUNTY
BETSY BAY

Fig. 4a

ranged from 0.33 to 13.0 mg/kg wet weight as shown in Fig. 4a. Values at Isle Royale were also somewhat higher than those reported at Bayfield, Wisconsin. Median values at Isle Royale were 0.73, 1.8, and 3.3 mg/kg (wet weight), respectively, for fish under 3 lb, 3 to 5 lb, and 5 to 10 lb, respectively, in 1974, and 3.1, 4.0, and 6.3 mg/kg (wet weight), respectively, in 1975.

Ontonagon lake trout samples (Fig. 4a) collected in June, 1974 ranged from 1.6 to 14.4 mg/kg (wet weight) in PCB concentration with median values of 2.2 mg/kg for five samples under 3 lb wet weight and 8.8 mg/kg for 17 samples in the 3 to 5 lb range. Samples collected in July, 1975 showed a median concentration of 2.7 mg/kg for the seven samples of fish under 3 lb wet weight, 6.6 for the six fish in the 3 to 5 lb range, and 5.0 for the five fish in the 5 to 10 lb range. In general, the median values were in the range of the samples collected at Isle Royale in 1975.

Much greater variations in PCB concentrations were observed in the samples collected at Calumet (Fig. 4a) with overall concentrations ranging from 0.02 mg/kg (wet weight) to 28.4 mg/kg (wet weight). Median values for fish collected at specific times and for various sizes were as follows: 6.9 mg/kg for seven fish less than 3 lb weight collected February, 1974; 0.38 for 11 fish less than 3 lb weight, 0.69 for six fish 3 to 5 lb weight, and 1.6 for 10 fish 5 to 10 lb weight collected in May, 1974; 1.2 mg/kg for three fish less than 3 lb weight, 2.3 for four fish 3 to 5 lb weight, 2.5 for four fish 5 to 10 lb weight, and 3.9 mg/kg for one fish over 10 lb weight collected in June, 1974; 8.6 mg/kg for five fish 3 to 5 lb weight and 5.5 mg/kg for 10 fish 5 to 10 lb weight collected in July, 1974; and 5.8 mg/kg for nine fish less than 3 lb weight, 2.2 for 10 fish 3 to 5 lb weight, and 3.3 for eight fish 5 to 10 lb weight collected in May, 1975.

Only a single sample was collected at Keweenaw in 1974 and again in 1977 (Fig. 4a) with PCB concentration of 4.5 mg/kg for a 5 to 10 lb fish, and 0.7 mg/kg for a 3 to 5 lb fish, respectively.

A total of 18 samples was collected at Betsy Bay in May, 1975 (Fig. 4a) with PCB concentrations in the range of 0.09 to 2.1 mg/kg wet weight. Median values showed an increase in size with values of 0.60 mg/kg for seven fish less than 3 lb weight, 0.76 for five fish in the 3 to 5 lb range, and 1.5 for six fish in the 5 to 10 lb range.

Thirty-six samples were collected in 1975 from an area designated MS-3 (Fig. 4b) and showed a range in PCB concentrations of 0.09 to 3.54 mg/kg wet weight. Median values were 0.65 for eleven fish, 1.45 for 13 fish, and 1.74 for 12 fish in the ≤ 3, 3 to 5, and 5 to 10 lb weight classes, respectively. In general, the concentrations observed in samples taken from area MS-3 were lower than values indicated for samples taken at specific locations in areas MS-1, MS-2, and MS-3. For fish weighing less than 3 lb, the median value for area MS-3 (1975) was 0.65 mg PCB/kg wet weight compared to 0.60 mg/kg for samples from Betsy Bay, 1975; 5.8 mg/kg Calumet, 1975; 2.7 mg/kg Ontonagon, 1974; and 3.1 mg/kg Isle Royale, 1975. For fish in the 3 to 5 lb group, only the sample taken from Betsy Bay had a lower median value (0.76 mg/kg) than did the samples taken from area MS-3 (1.45 mg/kg); all other median values were higher--Isle Royale, 4.04 mg/kg in 1975; Ontonagon, 6.57 mg/kg in 1974; and Calumet, 2.20 mg/kg in 1975. In the 5 to 10 lb group, the median value for samples from area MS-3 in 1975 was 1.74 mg/kg, was lower (1.41 mg/kg in 1975) for samples from Betsy Bay, and higher for all other locations--Bayfield, 2.7 mg/kg in 1974; Isle Royale, 6.29 in 1975; Ontonagon, 4.99 in 1974; Calumet, 3.30 in 1975; and Keweenaw Pt. (single sample, 4.5 mg/kg in 1974).

A number of lake trout samples were collected at Marquette, Michigan on Lake Superior during the period February, 1974 through May, 1975, the total being 112 samples (Fig. 4b). Overall PCB concentrations ranged from ≤ 0.02 to 24 mg/kg wet weight. Median values for specific sample periods and fish sizes were as follows: February, 1974, 10.5 mg/kg wet weight for four fish less than 3 lb weight; May, 1974, 0.66 mg/kg for 15 fish less than 3 lb weight, 0.99

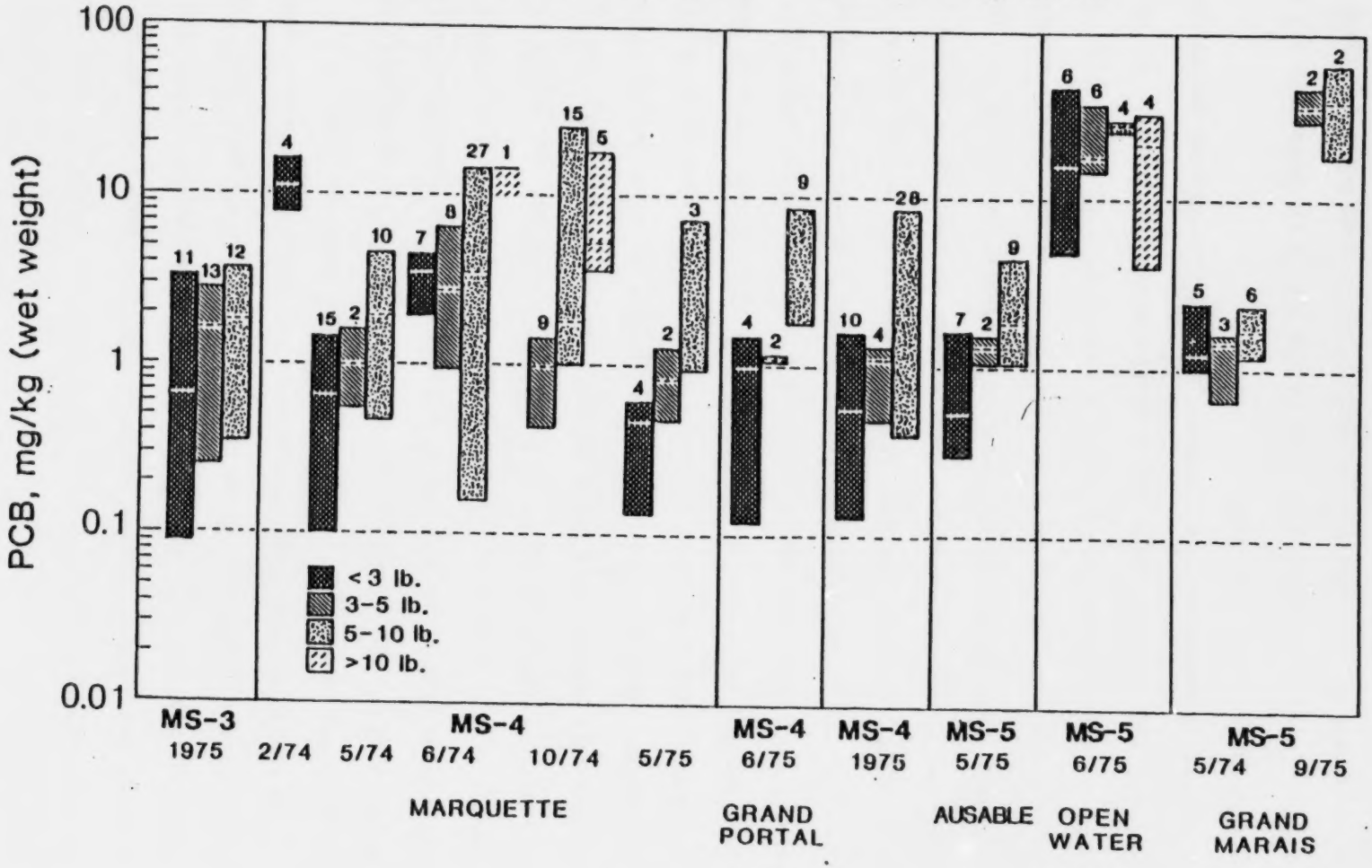

Lake Trout Data – Lake Superior
PCB, mg/kg (wet weight)
100
10
1
0.1
0.01
< 3 lb.
3-5 lb.
5-10 lb.
>10 lb.
MS-3
1975
MS-4
2/74
5/74
6/74
10/74
5/75
MS-4
6/75
MS-4
1975
MS-5
5/75
MS-5
6/75
MS-5
5/74
9/75
MARQUETTE
GRAND PORTAL
AUSABLE
OPEN WATER
GRAND MARAIS

Fig. 4b

for two fish 3 to 5 lb weight, and 2.0 for 10 fish 5 to 10 lb weight; June, 1974. 3.3 for seven fish less than 3 lb weight, 2.8 for eight fish 3 to 5 lb weight, 3.4 for 27 fish 5 to 10 lb weight, and 12.5 for one fish greater than 10 lb weight; October, 1974, 0.95 for nine fish 3 to 5 lb weight, 1.8 for 15 fish 5 to 10 lb weight, and 5.3 for five fish greater than 10 lb weight; and May, 1975, 0.48 for four fish less than 3 lb weight, 0.84 for two fish 3 to 5 lb weight, and 6.2 for three fish 5 to 10 lb weight. These data show a general increase in concentration with size in the individual samplings but the concentrations show increases and decreases with time with the June, 1974 median values showing higher values than samples collected in May, 1974, October, 1974, and May, 1975 levels.

Fifteen samples were collected in June, 1975 at Grand Portal, Michigan (Fig. 4b) and showed a PCB concentration range of 0.11 to 8.5 mg/kg wet weight. Median values for the three ranges of fish weight <3, 3 to 5, and 5 to 10 lb were 1.0, 1.1, and 3.1 mg/kg wet weight, respectively.

Forty-two samples were collected from area MS-4 Lake Superior (Fig. 1) with PCB concentrations ranging from 0.11 to 8.60 mg/kg. Median values for fish less than 3 lb, 3 to 5 lb, and 5 to 10 lb were 0.54, 1.04, and 2.04 mg/kg, respectively. Results reported in 1975 for area MS-4 were very similar to those reported for Marquette and Grand Portal (0.54, 0.48, and 1.0 mg/kg, respectively) for fish weight less than 3 lb; similar again for fish in the 3 to 5 lb group (1.04, 0.84, and 1.08 mg/kg, respectively); and were higher at both point locations for fish in the 5 to 10 lb group-2.04 mg/kg for MS-4, 6.20 mg/kg for Marquette, and 3.11 mg/kg for Grand Portal.

Eighteen fish collected in May, 1975 from Au Sable, Michigan (Fig. 4b) showed PCB concentrations ranging from 0.29 to 4.2 mg/kg wet weight. There was a general increase in reported concentrations with fish size as indicated by median values of 0.51 mg/kg for seven fish less than 3 lb weight, 1.2 for a

fish 3 to 5 lb weight, and 1.7 for nine fish 5 to 10 lb weight.

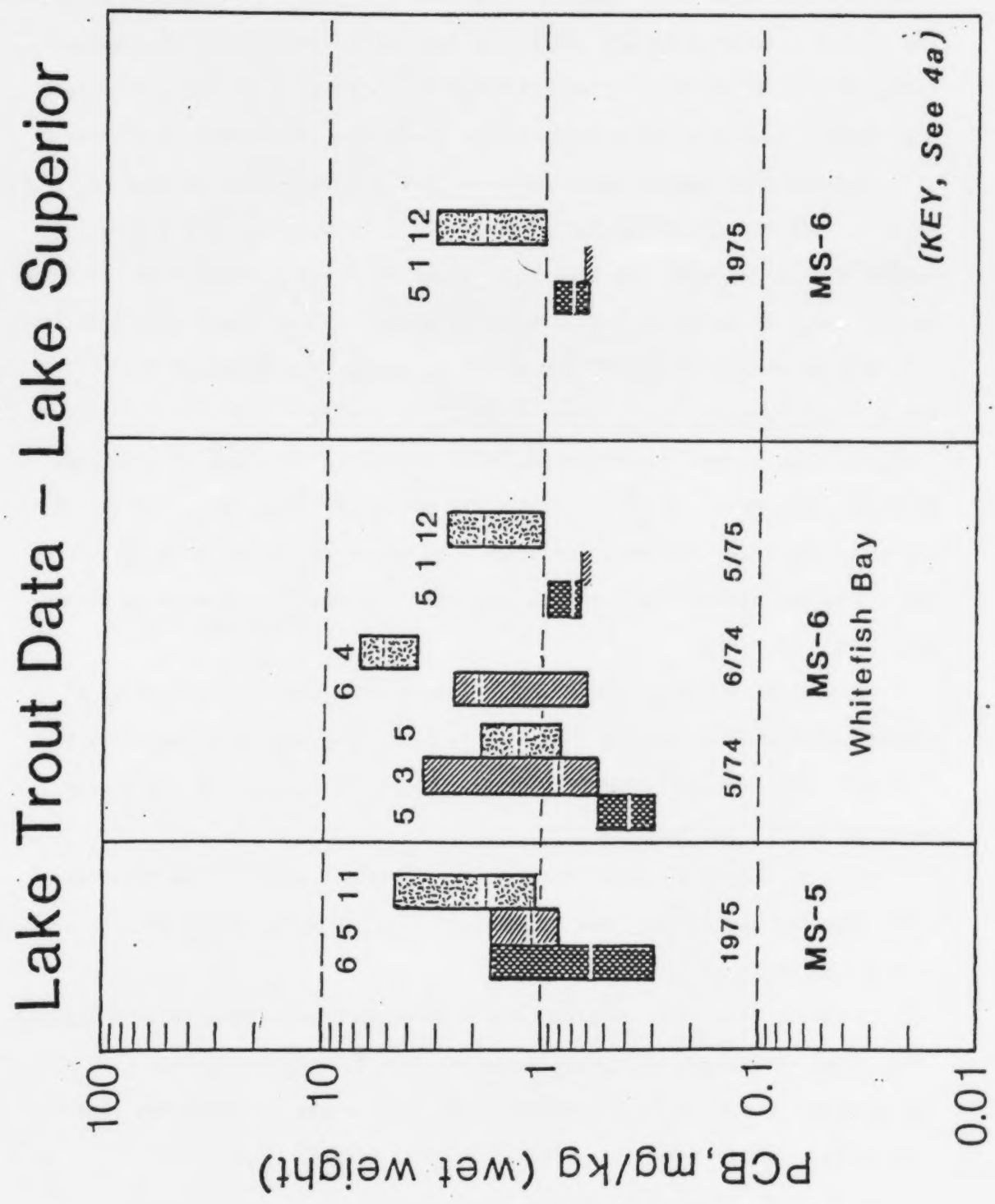
A series of 20 fish samples collected in June, 1975 from an area designated as open water in Lake Superior (area MS-5) showed relatively high PCB concentrations ranging from 4.0 to 45.2 mg/kg wet weight (Fig. 4b). Median values determined were 14.8 mg/kg for six fish less than 3 lb weight, 17.1 for six fish 3 to 5 lb weight, 27.2 for four fish 5 to 10 lb weight, and 20.4 for four fish greater than 10 lb weight.

Two series of samplings were reported for Grand Marais, Michigan (Area MS-5), one in May, 1974 and the other in September, 1975 (Fig. 4b). Both series showed an increase in median value with increase in fish size as follows: 1.1 mg/kg for five fish less than 3 lb weight, 1.3 for three fish 3 to 5 lb weight, and 1.5 for six fish 5 to 10 lb weight collected in 1974, and 36.8 mg/kg for two fish 3 to 5 lb weight, and 39.6 for two fish 5 to 10 lb weight in 1975. The 1975 sampling even though totaling only four fish had a concentration range for 17.7 to 61.6 mg/kg wet weight, the highest reported thus far along with the open water MS-5 area samples reported earlier with a range of 4.7 to 45.2 mg/kg wet weight.

Twenty-four samples were collected in the area MS-5, Lake Superior (Fig. 1) in 1975. These results were similar to those reported for Au Sable: Fish < 3 lb, 0.54 and 0.51 mg/kg; fish 3 to 5 lb, 1.95 and 1.20 mg/kg; and fish 5 to 10 lb, 1.72 and 1.72 mg/kg, respectively, for area MS-5 and Au Sable. Samples reported as being taken from Open Water MS-5 show considerably higher median values, namely: 14.8, 17.1, 27.2, and 10.4 mg/kg, respectively, for fish < 3 lb, 3 to 5 lb, 5 to 10 lb, and > 10 lb.

During three samplings taking place in Whitefish Bay, Michigan (area MS-6) in May, 1974, June, 1974, and May, 1975, 41 fish were collected for analysis (Fig. 4c). Overall range of PCB concentrations reported was 0.29 to 5.9 mg/kg wet weight. Median values determined were: 0.38 mg/kg for five fish less than 3 lb weight, 0.81 for three fish 3 to 5 lb weight, and 1.2 for five fish 5 to 10

Fig. 4c


Lake Trout Data – Lake Superior
PCB, mg/kg (wet weight)
100
10
1
0.1
0.01
6 5 11
1975
MS-5
5 3 5
6 4
5/74
6/74
5/75
MS-6
Whitefish Bay
5 1 12
5 1 12
1975
MS-6
(KEY, See 4a)

lb weight sampled in May, 1974; 1.9 mg/kg for six fish 3 to 5 lb weight and 5.2 for four fish 5 to 59 lb weight sampled in June, 1974; and 0.72 mg/kg for five fish less than 3 lb weight, 0.54 for one fish 3 to 5 lb weight, and 1.9 for 12 fish 5 to 10 lb weight sampled in May, 1975. In general, the median values showed an increase in concentration with size in each sampling period but showed variable median concentrations during the three sampling periods.

Eighteen fish samples were collected from an area designated MS-6 (Fig. 1) in 1975. PCB concentrations ranged from 0.62 to 3.12 mg/kg, with median values of 0.72 for fish less than 3 lb weight, 0.54 for a single fish 3 to 5 lb weight, and 1.87 mg/kg for fish 5 to 10 lb weight. These values were identical to a similar series of samples designated as coming from Whitefish Bay.

4.1.2. Lake Michigan (Figs. 2 and 4 d-e).

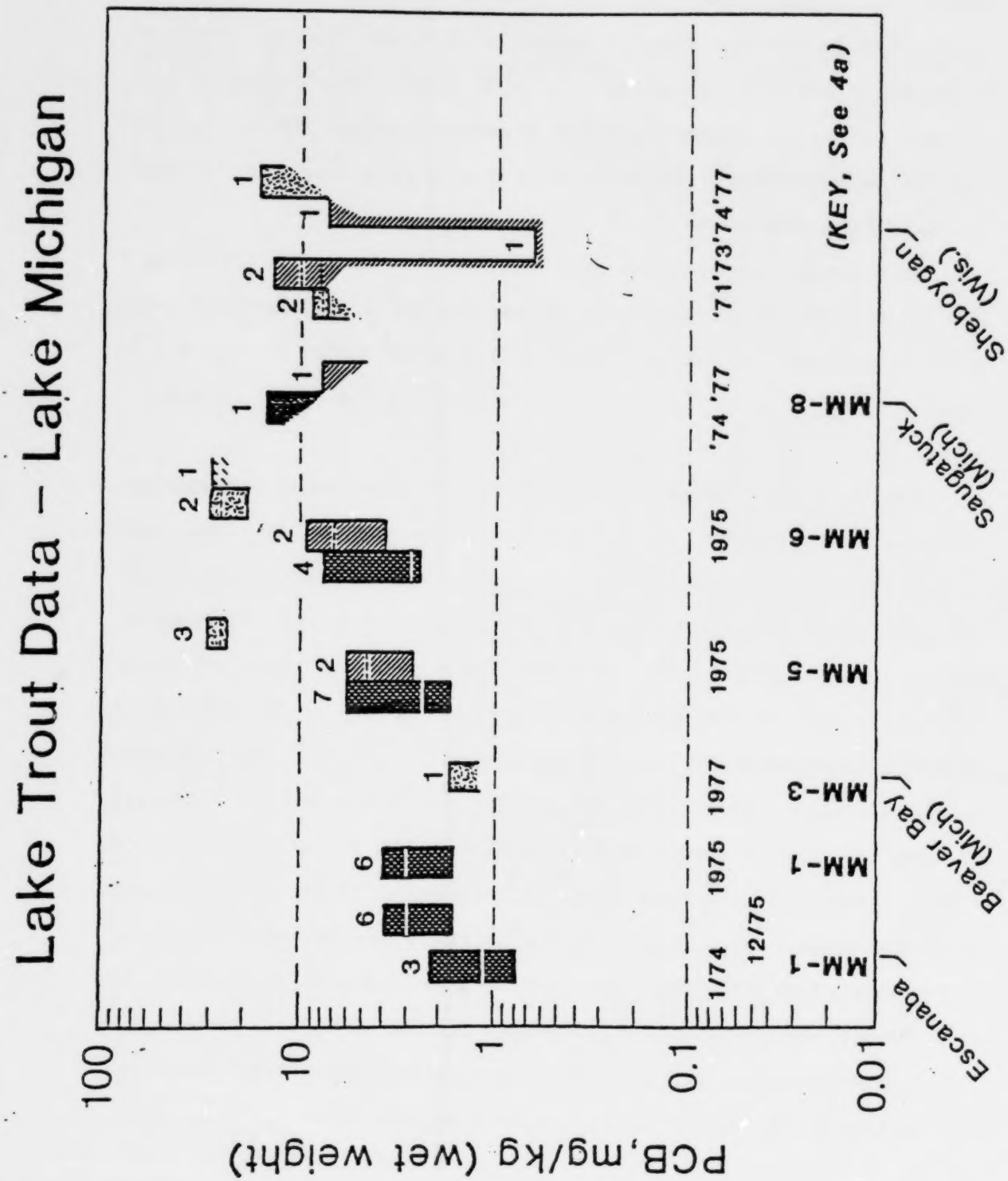
The range in PCB concentrations found in the two samplings at Escanaba, Michigan, area MM-1, was 0.74 to 3.5 mg/kg wet weight (Fig. 4d). The median value for the three fish each less than 3 lb weight collected in January, 1974 was 1.1 mg/kg, and for the six fish less than 3 lb weight collected in December, 1975, 2.67 mg/kg.

Six samples collected in 1975 from area MM-1 in Lake Michigan (Fig. 2) showed concentrations ranging from 1.40 to 3.50 mg/kg with a median value of 2.66 mg/kg for fish less than 3 lb weight, which is identical to the values reported in 1975 for Escanaba.

One fish sample was taken from the Beaver Island area in Lake Michigan in 1977 (Fig. 4d) and showed a PCB concentration of 1.6 mg/kg wet weight for a fish in the 5 to 10 lb weight class.

In 1975 12 fish were sampled in an area designated as MM-5 in Lake Michigan (Fig. 2 and 4d) ranged in PCB concentration from 1.66 to 29.4 mg/kg. The median values were: 2.10 for seven fish less than 3 lb weight, 4.19 for two fish 3 to 5 lb weight, and 23.6 for three fish 5 to 10 lb weight.

Fig. 4d


Lake Trout Data – Lake Michigan
PCB, mg/kg (wet weight)
100
10
1
0.1
0.01
Escanaba
Beaver Bay (Mich)
Saugatuck (Mich)
Sheboygan (Wis.)
MM-1
MM-3
MM-5
MM-6
MM-8
1/74
12/75
1975
1977
1975
1975
'74 '77
'71'73'74'77
(KEY, See 4a)

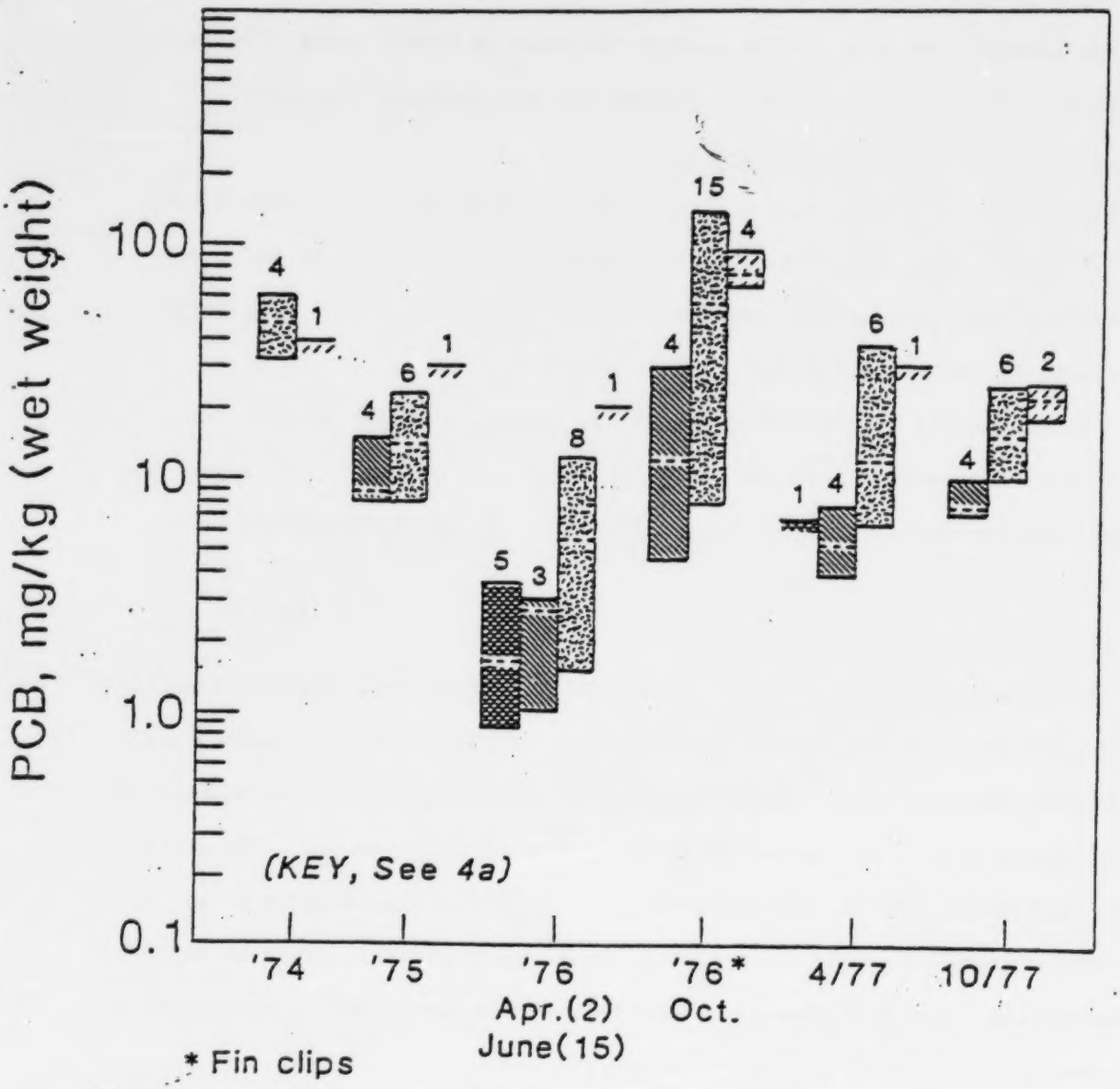
Also in 1975 nine fish were collected from area MM-6 (Fig. 2 and 4d) in Lake Michigan with PCB concentrations ranging from 2.25 to 28.85 mg/kg wet weight. The median values were: 2.61 mg/kg for four fish less than 3 lb weight, 6.56 for two fish 3 to 5 lb weight, 23.5 for two fish less than 5 to 10 lb weight, and 27.8 for one fish over 10 lb weight. One fish sample was obtained in 1974 and another in 1977 at Saugatuck, Michigan (MM-8) (Fig. 4d) with PCB concentrations of 13. mg/kg for a fish weighing less than 3 lb and 7.3 mg/kg for a fish in the 3 to 5 lb class, respectively.

Seven samples were collected from Sheboygan, Wisconsin (Fig 4d) during 1971 to 1977 with PCB concentrations ranging from 0.6 to 13.6 mg/kg and median values as follows: 7.8 for two fish 5 to 10 lb weight caught in 1971; 9.8 for two fish 3 to 5 lb weight caught in 1973; 0.6 for one fish 3 to 5 lb weight caught in 1977.

A series of fish samples was collected in the lower end of Lake Michigan (Indiana) and the results reported by Koch[6] are shown in Fig. 4e. Five samples of fish (each generally containing three fish) were collected in 1974, 11 in 1975, two in April, 1976, 15 in June, 1975, 23 in October, 1976, 12 in April, 1977, and 12 in October, 1977. Concentrations ranged from 0.86 to 122. mg/kg. Since only length of fish was reported, estimates of body weight were made from previously reported weight-length relationships (Appendix B). Specific median values determined follow: 1974, 44 mg/kg for four fish 5 to 10 lb weight and 37 mg/kg for one fish greater than 10 lb weight; 1975, 8.6 mg/kg for four fish 3 to 5 lb weight; 12.4 for six fish 5 to 10 lb weight; 30 for one fish greater than 10 lb weight; April-June, 1976, 1.5 for five fish less than 3 lb weight, 2.7 for three fish 3 to 5 lb weight, 5.3 for eight fish 5 to 10 lb weight, and 19.6 for one fish greater than 10 lb weight; October, 1976, 11.5 for four fish 3 to 5 lb weight, 55.2 for 15 fish 5 to 10 lb weight, and 71.8 for four fish greater than 10 lb weight (samples identified as "fin clips" for this area);

FIG. 4E

Lake Trout Data
Lake Michigan



SOUTHERN LAKE MICHIGAN
INDIANA DATA

April, 1977, 6.4 for one fish less than 3 lb weight, 5.0 for four fish 3 to 5 lb weight, 11.0 for six fish 5 to 10 lb weight, and 29.9 for one fish greater than 10 lb weight; and October, 1977, 7.3 for four fish 3 to 5 lb weight, 13.4 for six fish greater than 5 to 10 lb weight, and 20.4 for two fish greater than 10 lb weight. Overall these were among the highest concentrations found in fish and show a general increase in levels with size of fish (weight estimated from reported lengths) and also show a general increase in levels since 1976 except for the October, 1976 samples which carried the description "fin clips."

4.1.3. Lake Huron (See Fig. 2 and 4f).

Eighteen fish samples were collected in 1975 from an area in Lake Huron designated MH-1 (Fig. 2). Concentrations ranged from 0.36 to 2.76 mg/kg wet weight (Fig. 4f). The median concentration for 12 fish less than 3 lb weight was 0.93 mg/kg and for six fish 3 to 5 lb weight 2.10 mg/kg.

A single sample was collected in 1977 at Alpena, Michigan on Lake Huron and showed a PCB concentration of 4.6 mg/kg for a fish of 3 to 5 lb weight, and a single sample taken from Lake Huron, MH-5 (Fig. 2) had a PCB concentration of 5.7 mg/kg for a 5 to 10 lb fish.

4.2. Yellow Perch (Fig. 5).

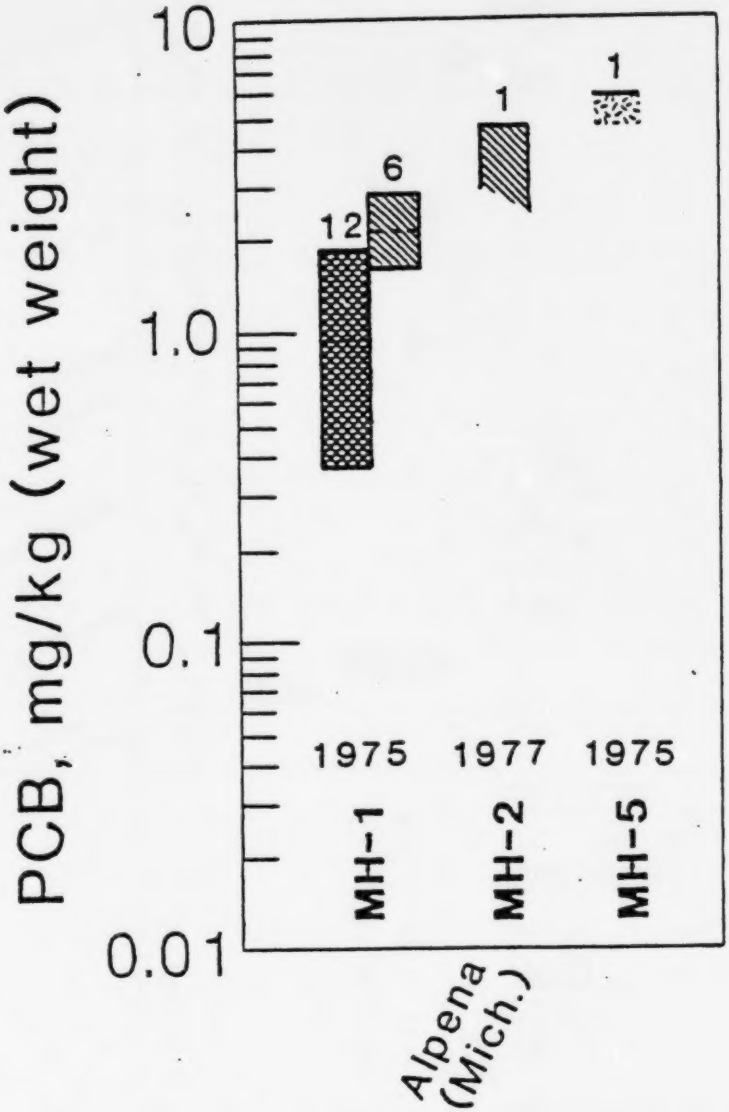
Preliminary responses from the commercial fishermen questionnaire identified yellow perch as the fish species most frequently consumed and/or consumed in the largest quantity. Information by source of sampling will now be summarized identifying levels of contamination observed in this fish species. The number of samples are rather limited amounting to only one or two fish sampled at any given time from a given location, but the data, even though minimal, might be helpful in identifying areas of higher concentration and the potential for increased human exposure.

4.2.1. Lake Michigan (Fig. 2 and 5).

Koch[6] reported data on yellow perch collected at the lower end of Lake

Fig. 4f

Lake Trout Data
Lake Huron



(KEY, See 4a)

Fat Trout (Lake Superior) and Yellow Perch

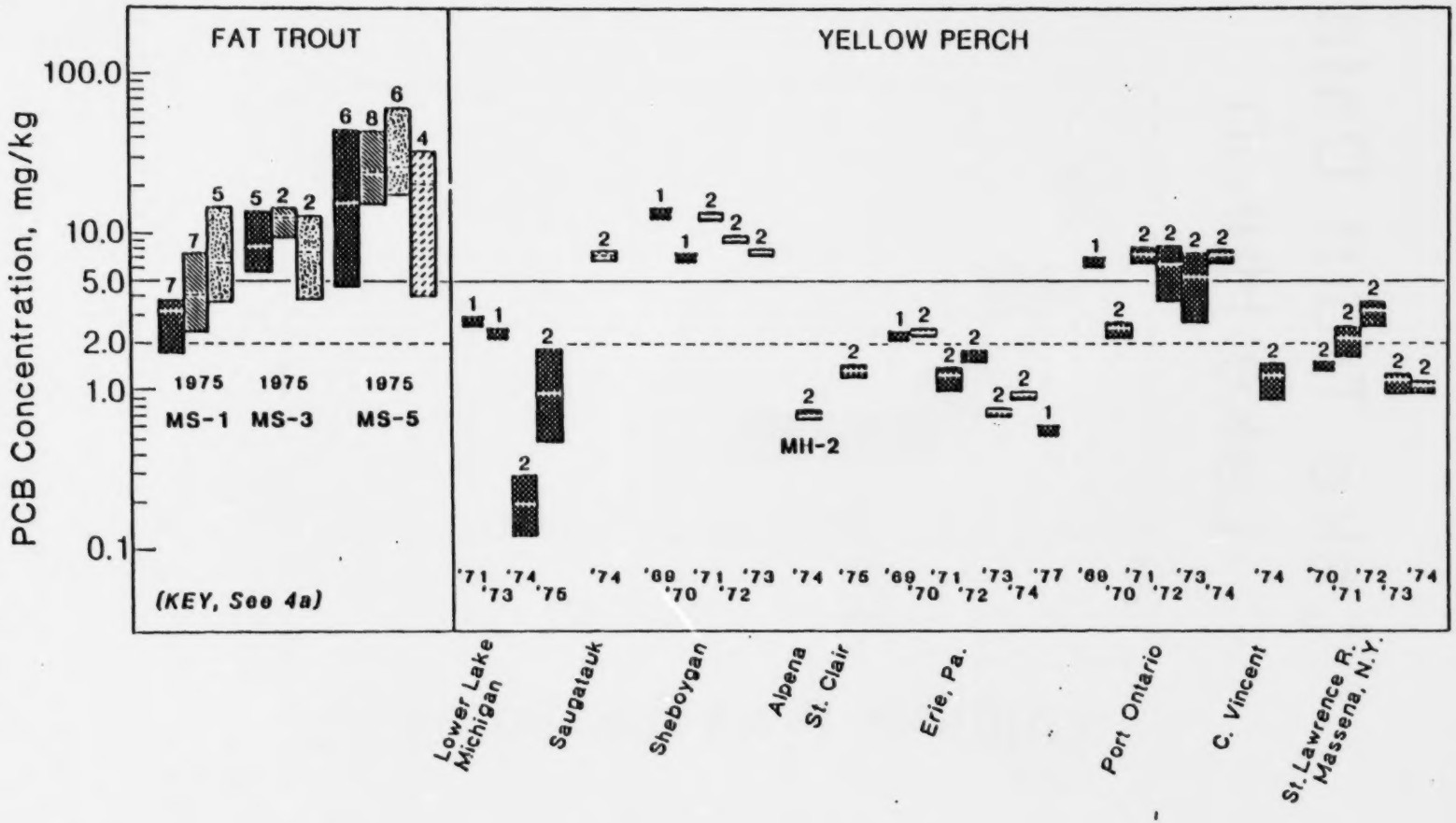


Fig. 5

Michigan in 1973 (one fish sample comprising 12 fish weighing 2.6 lb), 1974 (two fish samples each comprising six fish, one weighing 1.6 lb the other 2.0 lb), and 1975 (two fish samples one weighing 3.1 lb comprising five fish and the other 1.4 lb comprising nine fish). In addition, a single sample (1.5 lb) was collected in 1971 (the number of fish if more than one was not indicated) and the PCB concentration was reported at 3.0 mg/kg. As shown in Fig. 5, the concentration of PCB in the sample collected in 1973 was 2.4 mg/kg; the average values for the two samples each collected in 1974 and 1975 were 0.20 and 0.99 mg/kg, respectively.

Two samples collected at Saugatuck, Michigan (MM-8) in 1974 averaged 7.2 mg/kg for fish under 3 lb weight (Fig. 5).

Samples were collected at Sheboygan, Wisconsin over the period 1969 to 1973 (Fig. 5). PCB concentrations reported during this period follow: 1969, 12.6 mg/kg for one fish sample; 1970, 7.42 mg/kg for one fish sample; 1971, average 11.4 mg/kg for two fish samples; 1972, average 0.4 mg/kg for two fish samples; and 1973, average 7.8 mg/kg for two fish samples.

4.2.2. Lake Huron (Figs. 2 and 5).

Two samples of fish collected at Alpena, Michigan (MH-2) in 1974 yielded an average PCB concentration of 0.69 mg/kg.

4.2.3. Lake St. Clair (Figs. 2 and 5).

An average PCB concentration of 1.2 mg/kg was reported for two samples collected in Lake St. Clair in 1975.

4.2.4. Lake Erie (Figs. 3 and 5).

A series of samples was collected in Lake Erie at Erie, Pennsylvania. Reported concentrations for fish less than 3 lb weight were: 1969, 2.3 mg/kg for one sample; 1970, an average of 2.4 mg/kg for two samples; 1971, an average of 1.1 mg/kg for two samples; 1972, an average of 1.6 mg/kg for two samples; 1973, an average of 0.75 mg/kg for two samples; 1974, an average of 0.95 mg/kg for two samples; and 1977, 0.60 mg/kg for one fish sample.

4.2.5. Lake Ontario (Figs. 3 and 5).

A series of samples was collected at Port Ontario, New York. PCB concentrations reported for fish less than 3 lb weight follow: 1969, 7.1 mg/kg for a single fish sample; 1970, an average of 2.5 mg/kg for two fish samples; 1971, an average of 7.4 mg/kg for two fish samples; 1972, an average of 6.2 mg/kg for two fish samples; 1973, an average 5.2 mg/kg for two fish samples; and 1974, an average of 7.2 mg/kg for two fish samples.

Two samples of fish less than 3 lb weight were collected in 1974 at Cape Vincent, New York. Average PCB concentration was 1.1 mg/kg for the two samples collected.

4.2.6. St. Lawrence River (Figs. 3 and 5).

Samples were collected during the period 1970 to 1974 at Massena, New York. Average PCB concentrations for the two samples of fish less than 3 lb weight taken each year were: 1970, 1.4 mg/kg; 1971, 2.1 mg/kg; 1972, 3.2 mg/kg; 1973, 1.1 mg/kg; and 1974, 1.0 mg/kg.

4.3. Lake Whitefish (Fig. 6).

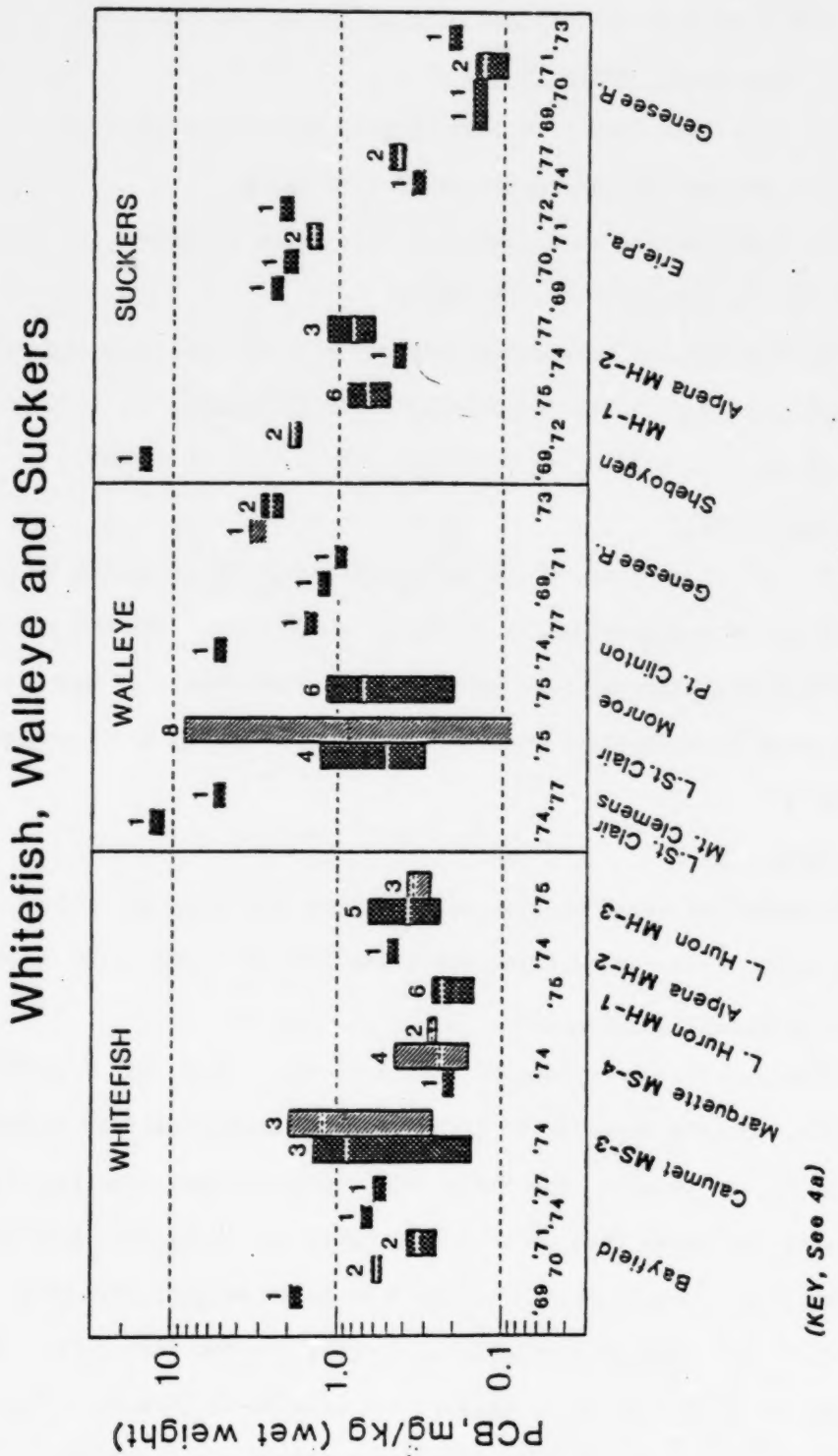
Lake whitefish were identified as the second most preferred fish in the preliminary results of the epidemiological survey of commercial fishermen. A few data are available on levels of PCB in this specie of fish taken from various locations in Lake Superior and Lake Huron (Figs. 1 and 2).

4.3.1. Lake Superior (Figs. 1 and 6).

A few samples of lake whitefish were collected over the period 1969 to 1977 at Bayfield, Wisconsin. All fish collected weighed less than 3 lb (Fig. 6). PCB levels found were as follows: 1969, 2.0 mg/kg for one fish sample; 1970, average of 0.58 mg/kg for two samples; 1971, an average of 0.31 mg/kg for two samples; 1974, 0.70 mg/kg for one sample; and 1977, 0.6 mg/kg for one fish sample.

Six fish were sampled at Calumet, Michigan (MS-3) in 1974. Levels of PCB reported (Fig. 6) were as follows: 0.83 mg/kg for three fish less than 3 lb weight, and 1.1 mg/kg for three fish 3 to 5 lb weight.

Fig. 6


Whitefish, Walleye and Suckers
PCB, mg/kg (wet weight)
10
1.0
0.1
WHITEFISH
WALLEYE
SUCKERS
Bayfield
Calumet MS-3
Marquette MS-4
L. Huron MH-1
Alpena MH-2
L. Huron MH-3
L. St. Clair
Mt. Clemens
L. St. Clair
Monroe
Pt. Clinton
Genesee R.
Sheboygen
MH-1
Alpena MH-2
Erie, Pa.
Genesee R.
(KEY, See 4a)

In 1974, seven fish were sampled at Marquette, Michigan (Fig. 6) with PCB levels as follows: 0.22 mg/kg for one fish under 3 lb weight, 0.28 mg/kg for four fish 3 to 5 lb weight; and 0.38 mg/kg for two fish 5 to 10 lb weight.

4.3.2. Lake Huron (Figs. 2 and 6).

Six fish each less than 3 lb weight, were collected from area MH-1 in 1975 and had a median PCB concentration of 0.22 mg/kg.

One fish, weight less than 3 lb, was taken at Alpena, Michigan in 1974 and had a PCB concentration of 0.51 mg/kg.

Several samples were collected from area MH-3 in 1975 and yielded the following results: a median concentration of 0.38 mg/kg for five fish less than 3 lb weight; and 0.22 mg/kg for three fish 3 to 5 lb weight.

4.4. Lake Herring.

The fourth species of fish most preferred, as indicated by preliminary data from the epidemiological survey of commercial fishermen was the lake herring. Unfortunately, only one fish sample weight less than 3 lb was collected in 1974 at Keweenaw Pt., Michigan on Lake Superior and showed a PCB concentration of 1.1 mg/kg.

4.5. Other Fish.

A number of other species of fish were collected at various locations on the Great Lakes or its tributaries and these data are summarized below.

4.5.1. Fat Trout (Fig. 5).

Nineteen fish were sampled from area MS-1, nine from area MS-3, and 24 from area MS-5 in Lake Superior in 1975. The PCB concentrations varied from 1.7 to 61.6 mg/kg wet weight. The median PCB concentrations reported were: Area MS-1, 3.1 mg/kg for seven fish under 3 lb weight, 4.0 mg/kg for seven fish 3 to 5 lb weight, and 6.3 mg/kg for five fish 5 to 10 lb weight; area MS-3, 8.4 mg/kg for five fish less than 3 lb weight, 11.3 mg/kg for two fish 3 to 5 lb weight, and 7.7 for two fish 5 to 10 lb weight; and area MS-5, 14.8 mg/kg for six fish less than 3 lb. weight, 23.3 mg/kg for eight fish 3 to 5 lb weight, 27.2 mg/kg for

six fish 5 to 10 lb weight, and 20.4 mg/kg for four fish greater than 10 lb weight.

4.5.2. Brown Trout (Fig. 7).

Brown trout were sampled in area MH-2 Lake Huron in 1975. Six fish were sampled with the following results: Three fish less than 3 lb weight, 0.64 mg/kg; two fish 3 to 5 lb weight, 1.7 mg/kg; and one fish 5 to 10 lb weight, 1.1 mg/kg.

4.5.3. Rainbow Trout (Fig. 7).

One fish sample was collected in Lake Erie at Monroe, Michigan in 1975 and had a PCB concentration of 0.70 mg/kg for a fish less than 3 lb weight.

4.5.4. Carp (Fig. 8).

Carp were collected in Lake Huron in areas MH-4 and MH-5 in 1975. Results were as follows: MH-4, 1.0 mg/kg for three fish 3 to 5 lb weight, and 1.8 mg/kg for five fish 5 to 10 lb weight; MH-5, 0.40 mg/kg for six fish less than 3 lb weight, 1.2 mg/kg for four fish 3 to 5 lb weight, and 2.8 mg/kg for two fish 5 to 10 lb weight.

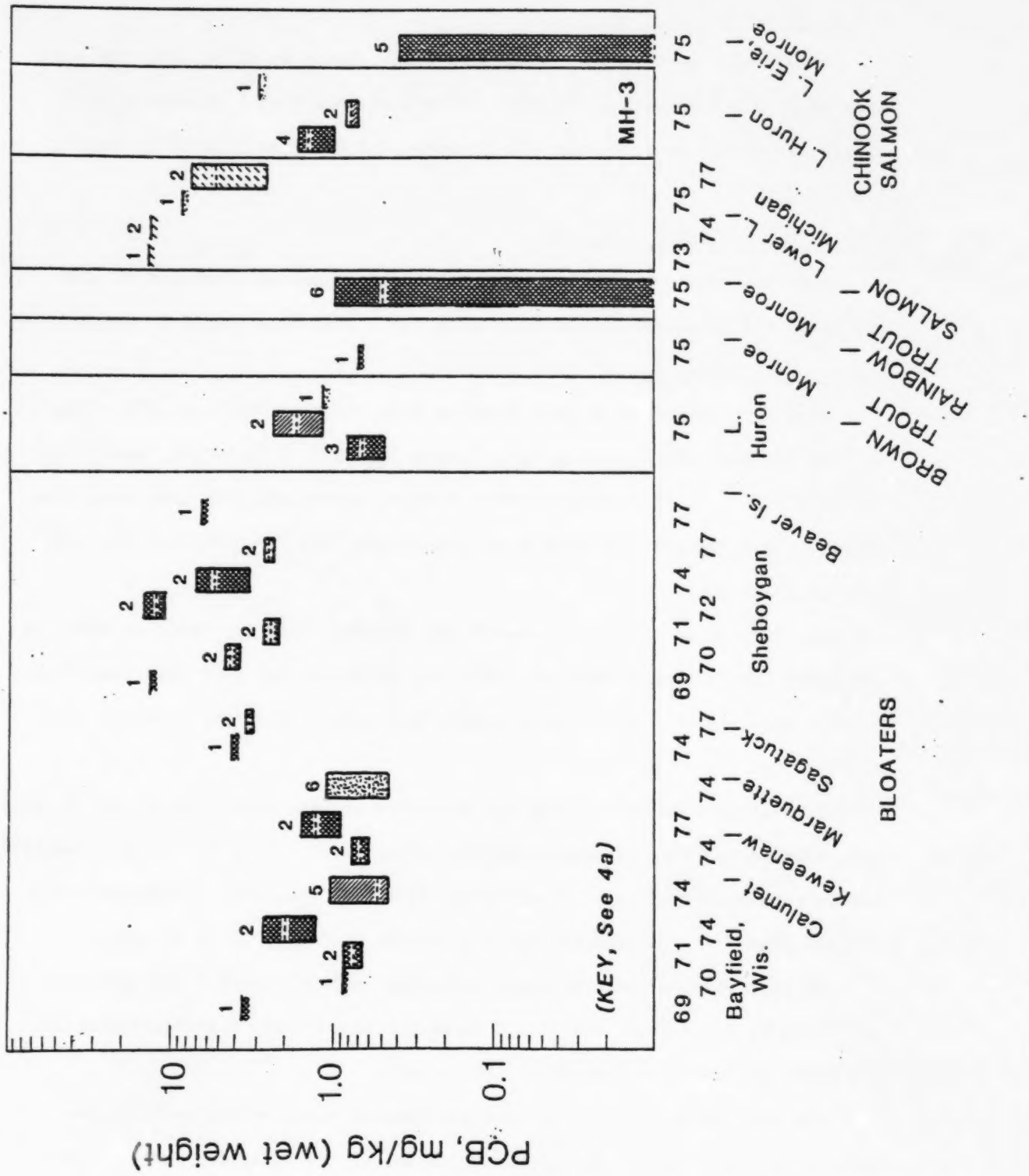
Two samples of fish were taken at Mt. Clemens, Lake St. Clair in 1974 and 1975 with the following results: 1974, 4.1 mg/kg for two fish less than 3 lb weight; and 1977, 5.7 mg/kg for one fish less than 3 lb weight, and 4.2 mg/kg for one fish 3 to 5 lb weight.

Samples were collected form two locations on Lake Erie. At Monroe, Michigan, sampled in 1975, PCB concentrations ranged from 1.0 to 6.5 mg/kg. Specific median concentrations were 2.4 mg/kg for five fish less than 3 lb weight, 2.8 for six fish 3 to 5 lb weight, and 3.9 for one fish 5 to 10 lb weight.

At Port Clinton, Ohio a sample collected in 1974 showed a concentration of 1.3 mg/kg for a fish less than 3 lb weight and in 1977 a concentration of 2.8 mg/kg for two fish less than 3 lb weight.

Two samples were collected from the Genesee River at Scottsville, New York in 1977 and had an average concentration of 2.5 mg/kg for two fish less

Fig. 7


PCB, mg/kg (wet weight)
10
1.0
0.1
(KEY, See 4a)
MH-3
BLOATERS
CHINOOK SALMON
BROWN TROUT
RAINBOW TROUT
SALMON
69 71 74 77
70 74
Bayfield, Wis.
Calumet
Keweenaw
Marquette
Sagatuck
69 71 74 77
70 72 77
Sheboygan
Beaver Is.
75
L. Huron
Monroe
75 75 73 75
74 77
Lower L. Michigan
Monroe
75
L. Huron
75
L. Erie, Monroe

Carp, Catfish, and Channel Catfish

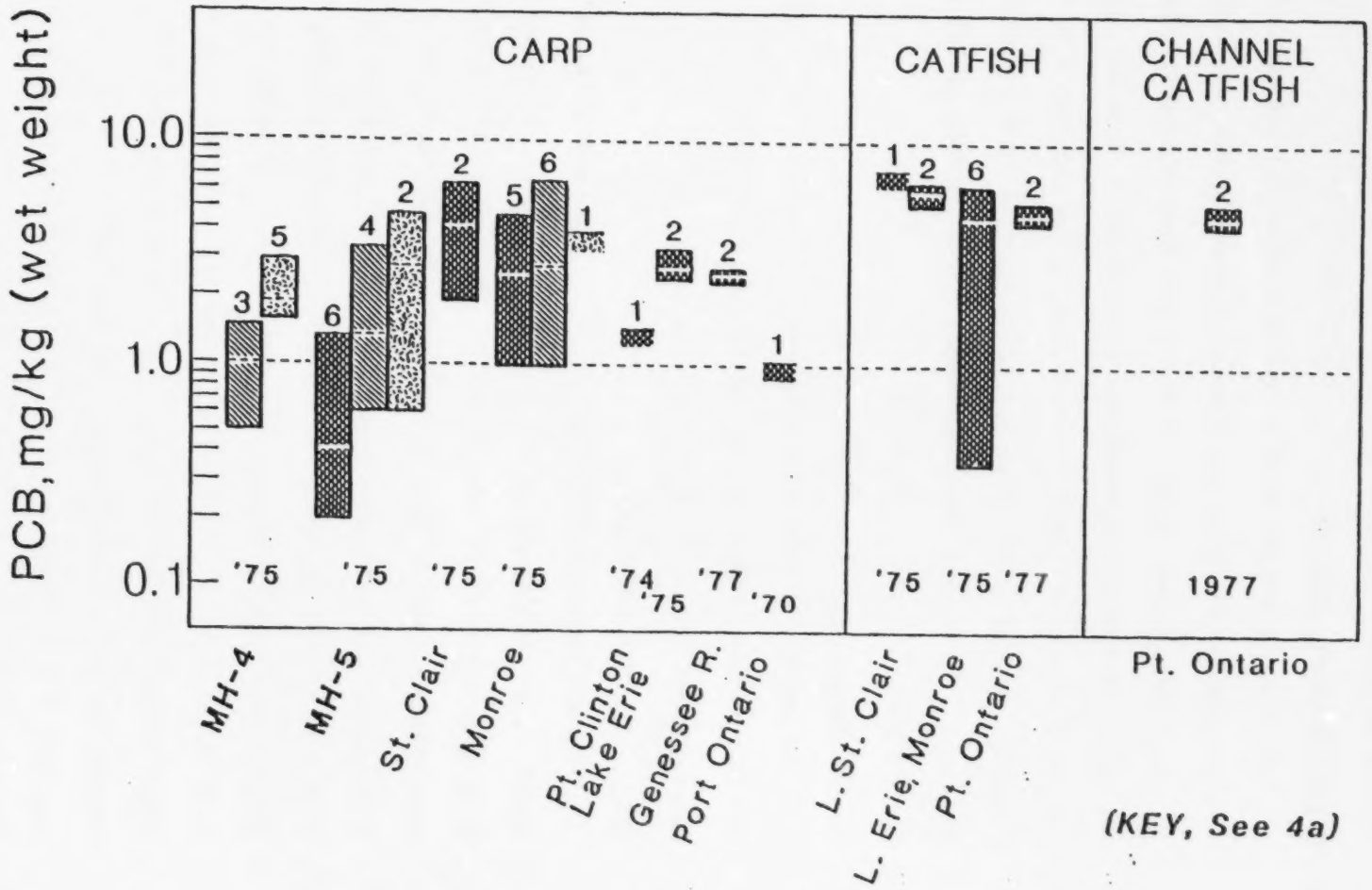


Fig. 8

than 3 lb weight.

A single sample collected from Lake Ontario at Port Ontario, New York in 1970 had a PCB concentration of 1.0 mg/kg for a fish less than 3 lb weight.

4.5.5. Catfish (Fig. 8).

Catfish were sampled in 1975 from Lake St. Clair and Lake Erie at Monroe, Michigan and in 1977 from Lake Ontario at Port Ontario, New York. The Lake St. Clair samples were higher in PCB levels than those collected from the other two sites. Specific concentrations observed were: Lake St. Clair, 7.7 mg/kg for one fish 3 to 5 lb weight, and 6.0 mg/kg for two fish 5 to 10 lb weight; Lake Erie at Monroe, Michigan, 4.8 mg/kg (range 0.36 to 6.5 mg/kg) for 6 fish less than 3 lb weight; and Lake Ontario at Port Ontario an average of 4.9 mg/kg for two fish less than 3 lb weight.

4.5.6. Channel Catfish (Fig. 8).

Two samples of channel catfish were collected in 1977 at Port Ontario, New York on Lake Ontario and had an average PCB concentration of 4.9 for the two fish less than 3 lb weight.

4.5.7. Walleye (Fig. 6).

Walleye were collected from Lake St. Clair, Lake Erie, and the Genesee River. The results were as follows: Lake St. Clair at Mount Clemens: 1974, 12.0 mg/kg for one fish less than 3 lb weight, and 1977, 5.7 mg/kg for one fish less than 3 lb weight; Lake St. Clair: 1975, 0.50 mg/kg for four fish less than 3 lb weight, and 0.85 mg/kg (range 0.01 to 8.40) for eight fish 3 to 5 lb weight; Lake Erie at Monroe, Michigan: 1975, 0.70 mg/kg for six fish less than 3 lb weight; Lake Erie at Port Clinton, Ohio: 1974, 5.7 mg/kg for one fish less than 3 lb weight, and 1977, 1.5 mg/kg for one fish less than 3 lb weight; Genesee River at Scottsville, New York: 1969, 1.2 mg/kg for one fish less than 3 lb weight, 1971, 1.0 mg/kg for one fish less than 3 lb weight, and 3.3 mg/kg for one fish 3 to 5 lb weight, and 1973, 2.6 mg/kg for two fish less than 3 lb weight.

4.5.8. Sucker (Fig. 6).

Sucker were sampled in Lakes Michigan, Huron, and Erie, and in the Genesee River. Results for fish less than 3 lb weight follow: Lake Michigan, at Sheboygan, Wisconsin: 1969, 1.9 mg/kg for one fish and 1974, 1.8 mg/kg for two samples; Lake Huron (area MH-1): 1975, 0.63 mg/kg for six fish; Lake Huron at Alpena, Michigan (area MH-2): 1974, 0.46 mg/kg for one fish and 1977, 0.80 mg/kg for three fish; Lake Erie at Erie, Pennsylvania: 1969, 2.5 mg/kg for one fish, 1970, 2.1 mg/kg for one fish, 1971, 1.3 mg/kg for two fish, 1972, 2.2 mg/kg for one fish, 1974, 0.35 mg/kg for one fish, and 1977, 0.45 mg/kg for two fish; and the Genesee River at Scottsville, New York: 1969, 1.5 mg/kg for one fish, 1970, 1.6 mg/kg for one fish, 1971, 1.2 mg/kg for two fish, and 1973, 2.2 mg/kg for one fish.

4.5.9. Red Sucker (Fig. 9).

This species was sampled only in the Genesee River, Scottsville, New York. Results for fish less than 3 lb weight were: 1970, 1.8 mg/kg for one sample; 1972, 1.4 mg/kg for one fish; and 1974, 0.42 mg/kg for one fish.

4.5.10. Bloater (Fig. 7).

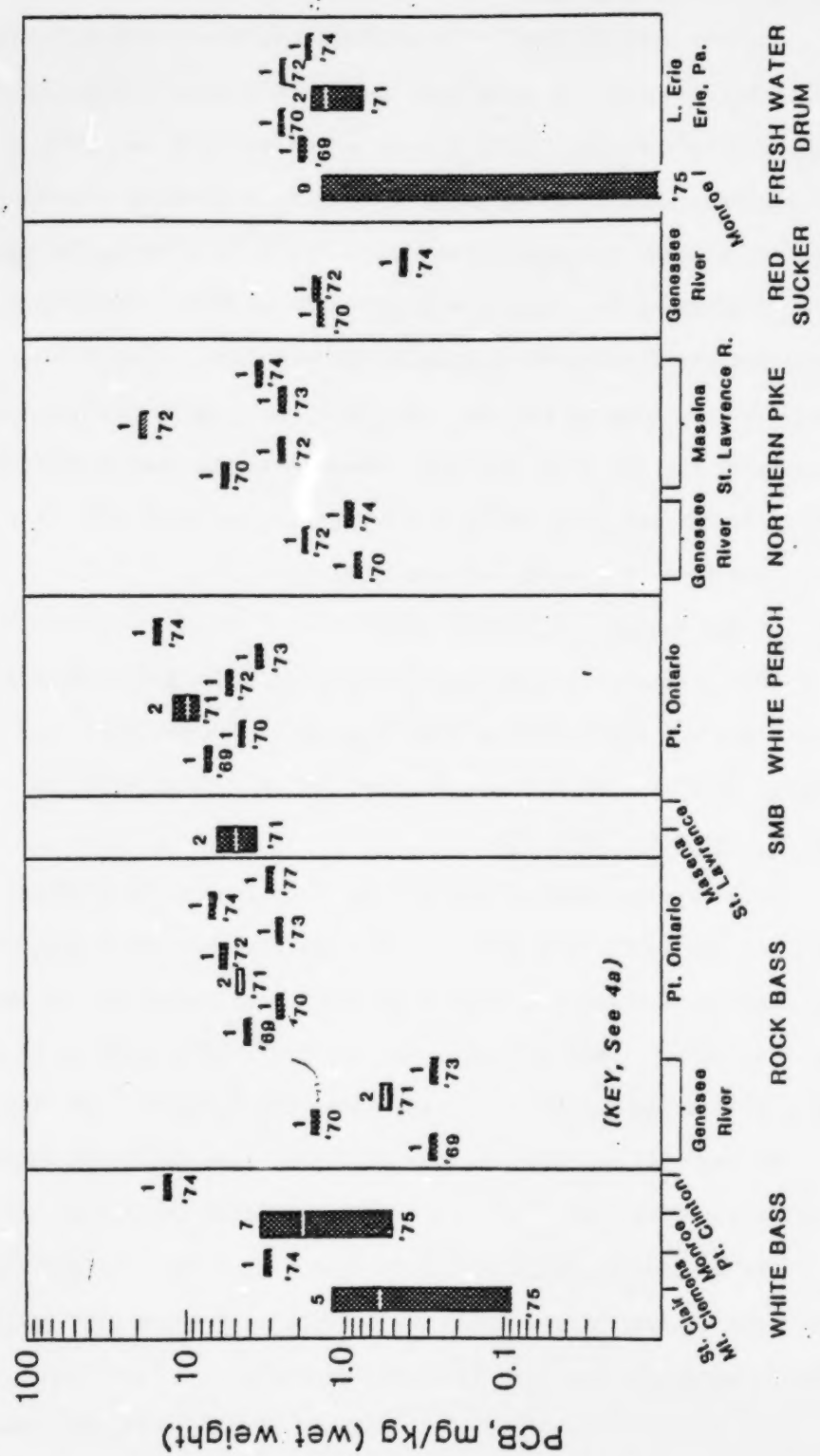
Bloater were sampled from several locations on Lakes Superior and Michigan. At Bayfield, Wisconsin on Lake Superior, PCB concentrations reported for samples weighing less than 3 lb weight, collected during the period 1969 to 1974, were: 1969, 3.5 mg/kg for one fish; 1970, 0.89 mg/kg for one fish; 1971, 0.76 mg/kg for two fish; and 1974, 2.0 mg/kg for two fish.

At Calumet, Michigan on Lake Superior (area MS-3) the median PCB concentration for five fish 3 to 5 lb weight collected in 1974 was 0.52 mg/kg.

The concentration in fish less than 3 lb weight at Keweenaw Point, Michigan, Lake Superior (area MS-3) was 0.70 mg/kg for two fish collected in 1974 and 1.2 mg/kg for two fish collected in 1977.

Six fish weighing 5 to 10 lb caught off Marquette, Michigan in Lake Superior (area MS-4) had a median concentration of 0.60 mg/kg. Fish collected

Fig. 9


PCB, mg/kg (wet weight)
100
10
1.0
0.1
WHITE BASS
ROCK BASS
SMB
WHITE PERCH
NORTHERN PIKE
RED SUCKER
FRESH WATER DRUM
St. Clair
Mt. Clemens
Monroe
Pt. Clinton
Genesee River
Pt. Ontario
Massena
St. Lawrence
Genesee River
Massena St. Lawrence R.
Genesee River
Monroe
L. Erie
Erie, Pa.
(KEY, See 4a)

at Saugatuck, Michigan on Lake Michigan (area MM-8) in 1974 showed a PCB concentration of 4.2 mg/kg for one fish less than 3 lb weight and in 1977, 3.2 mg/kg for two fish less than 3 lb weight.

A series of fish samples less than 3 lb weight was collected at Sheboygan, Wisconsin on Lake Michigan during the period 1969 to 1977. Results were: 1969, 12.4 mg/kg for one sample; 1970, 4.4 mg/kg for two samples; 1971, 2.4 mg/kg for two samples; 1973, 12.3 mg/kg for two fish; 1974, 5.4 mg/kg for two fish; and 1977, 2.4 mg/kg for two fish.

A single fish less than 3 lb weight was caught in 1977 at Beaver Island, Michigan, Lake Michigan (area MM-3) and had a PCB concentration of 6.8 mg/kg.

4.5.11. Burbot.

This species of fish was collected from Lake Michigan at Escanaba, Michigan (area MM-1) in 1974 and 1975. Results were: 1974, 0.23 mg/kg for two fish 3 to 5 lb weight, and 5.6 mg/kg for one fish 5 to 10 lb weight; and 1975, 0.24 mg/kg for six fish less than 3 lb weight.

4.5.12. White Bass (Fig. 9).

White bass were collected form Lakes St. Clair and Erie. In 1975, five fish less than 3 lb weight from Lake St. Clair had a PCB concentration of 0.60 mg/kg (range 0.01 to 1.1). A single fish less than 3 lb weight from Mt. Clemens, Michigan, collected in 1974 had a PCB concentration of 3.1 mg/kg.

Seven fish less than 3 lb weight taken in 1975 at Monroe, Michigan on Lake Erie had a concentration of 1.8 mg/kg (range 0.50-3.30) and one fish less than 3 lb weight from Lake Erie at Port Clinton, Ohio caught in 1974 had a concentration of 12.0 mg/kg.

4.5.13. Rock Bass (Fig. 9).

Rock bass were taken from the Genesee River at Scottsville, New York and Port Ontario on Lake Ontario in New York. The results for fish less than 3 lb weight taken from the Genesee River were: 1969, 0.39 mg/kg for one fish; 1970, 1.5 mg/kg for one fish, 1971, 0.55 mg/kg for two fish; and 1973, 0.28 mg/kg for one fish.

4.5.14. Smallmouth Bass (Fig. 9).

Two samples of this fish were taken from the St. Lawrence River at Massena, New York in 1971. Results averaged 4.70 mg/kg (range 3.3 to 6.1) for the two fish less than 3 lb weight.

4.5.15. White Perch (Fig. 9).

During the period 1969 to 1974 seven samples of white perch under 3 lb weight were collected at Port Ontario, New York on Lake Ontario. Results were: 1969, 7.7 mg/kg for one fish; 1970, 4.7 mg/kg for one fish; 1971, 9.8 mg/kg for two fish; 1972, 5.6 mg/kg for one fish; 1977, 3.5 mg/kg for one fish; and 1974, 14.1 mg/kg for one fish.

4.5.16. Northern Pike (Fig. 9).

This specie of fish was sampled during 1970 to 1974 at Scottsville, New York on the Genesee River and Massena, New York on the St. Lawrence River. Results were: Genesee River: 1970, 0.85 for one fish less than 3 lb weight; 1972, 1.8 mg/kg for one fish less than 3 lb weight; and 1974, 0.98 mg/kg for one fish less than 3 lb weight; St. Lawrence River: 1970, 0.85 mg/kg for one fish less than 3 lb weight; 1972, 3.6 mg/kg for one fish less than 3 lb weight, and 19.0 mg/kg for one fish 3 to 5 lb weight; 1973, 2.6 mg/kg for one fish less than 3 lb weight; and 1974, 3.5 mg/kg for one fish less than 3 lb weight.

4.5.17. Fresh Water Drum (Fig. 9).

This fish was sampled in Lake Erie at Monroe, Michigan and Erie, Pennsylvania. The PCB concentrations in fish less than 3 lb weight were: Monroe: 0.01 mg/kg (range 0.01 to 1.2 mg/kg) for nine fish sampled in 1975; and Erie: 1969, 1.9 mg/kg for one fish; 1970, 2.5 mg/kg for one fish; 1971, 1.1 mg/kg for two fish; 1972, 2.5 mg/kg for one fish; and 1974, 1.8 mg/kg for one fish.

4.5.18. Black Crappie.

Two fish were sampled at Scottsville, New York on the Genesee River in 1974 and yielded 0.88 mg PCB/kg for fish less than 3 lb weight.

4.5.19. Brown Bullhead.

A single sample was collected in 1974 at Cape Vincent, Lake Ontario, and showed a concentration of 3.2 mg/kg for a fish less than 3 lb weight.

4.5.20. Muskie.

Two fish were collected from Lake St. Clair in 1975 each weighing more than 10 lbs. PCB concentrations ranged from 0.01 to 3.0 mg/kg with an average value of 1.5 mg/kg.

4.5.21. Salmon (Fig. 7).

In 1975, six salmon weighing less than 3 lb each were taken from Lake Erie at Monroe, Michigan and had a median PCB concentration of 0.50 mg/kg (range 0.01 to 1.00 mg/kg).

4.5.22. Chinook Salmon (Fig. 7).

These fish were taken from lower Lake Michigan in Indiana, Lake Huron (area MH-3), and Lake Erie at Monroe, Michigan. Concentrations reported were as follows: Lower Lake Michigan: 1973, 12.4 mg/kg for one fish greater than 10 lb weight; 1974, 12.3 mg/kg for two fish greater than 10 lb weight; 1975, 8.8 mg/kg for one fish 5 to 10 lb weight; and 1977, 5.2 mg/kg (range 2.5 to 7.8 mg/kg) for two fish greater than 10 lb weight; Lake Huron: 1975, 1.3 mg/kg for four fish less than 3 lb weight, 0.77 mg/kg for two fish 3 to 5 lb weight, and 3.0 mg/kg for one fish 5 to 10 lb weight, and Lake Erie: 1975, 0.40 mg/kg (range 0.01 to 0.40 mg/kg) for five fish less than 3 lb weight.

4.5.23. Cisco.

Several cisco under 3 lb weight were taken from Lake Superior in 1974 from Calumet, Michigan (area MS-3) and Marquette, Michigan (area MS-4). Results were: Calumet, 0.85 mg/kg for six fish; Marquette, 0.19 mg/kg for three fish.

4.5.24. Smelt.

Results on only one fish less than 3 lb weight were reported and amounted to 0.65 mg/kg. This sample was collected in 1975 from Lake Huron (area MH-1).

5.0. Discussion.

As stated earlier, the four fish species in order of preference, as indicated

from a preliminary evaluation of the references of commercial fishermen in the Great Lakes area, were yellow perch, lake whitefish, lake herring, and lake trout. The most extensive data available for review were those pertaining to lake trout, particularly data available from the State of Michigan, which collected samples from Lake Superior, Lake Michigan, and Lake Huron in 1975.

Since samples were collected in different years, to get a true representation of changes in PCB concentrations levels it would have been desirable to have data on the age of the fish caught for analysis. Unfortunately, such data were not available and relations, therefore, had to be established between weight and length, between length and PCB concentration, and between weight and PCB concentration. Weight-length relationships were desirable when the data contained one of these parameters and not the other. Age of fish would have helped in attempts to relate PCB concentration and to reported lengths or weights of fish.

5.1. Lake Trout.

To define the nature of the distribution of PCB levels in lake trout some of the data reported specifically for areas MS-3, MS-4, MS-5, and MS-6 for Lake Superior were plotted on log probability paper and established the fact that levels followed a geometric distribution rather than an arithmetic one. The plot (Fig. 10) indicates that for this distribution of lake trout data, the 50 percent value or geometric mean amounted to 1.3 mg/kg with a geometric standard deviation of 2.21 ($M_g \overset{x}{\div} \sigma_g$ = $1.3 \overset{x}{\div} 2.21$). If the assumption is made that this distribution is characteristic of all lake trout in Lake Michigan, these data show that only 4.5 percent of the fish would exceed the current FDA permissible concentration in fish tissue of 5 mg/kg. If the value is reduced to 2 mg/kg than approximately 29 percent of the fish would exceed this value.

If these same data were replotted in the basis of the three fish weights-- < 3, 3 to 5, and 5 to 10 lb, the distributions are those shown in Fig. 11. It will be noted that much greater variations occur in the fish under 3 lb, but the other two distributions by weight are consistant and show the log normal distribution. The approximate characteristics of these three curves are: For fish less than 3 lb

Fig. 10

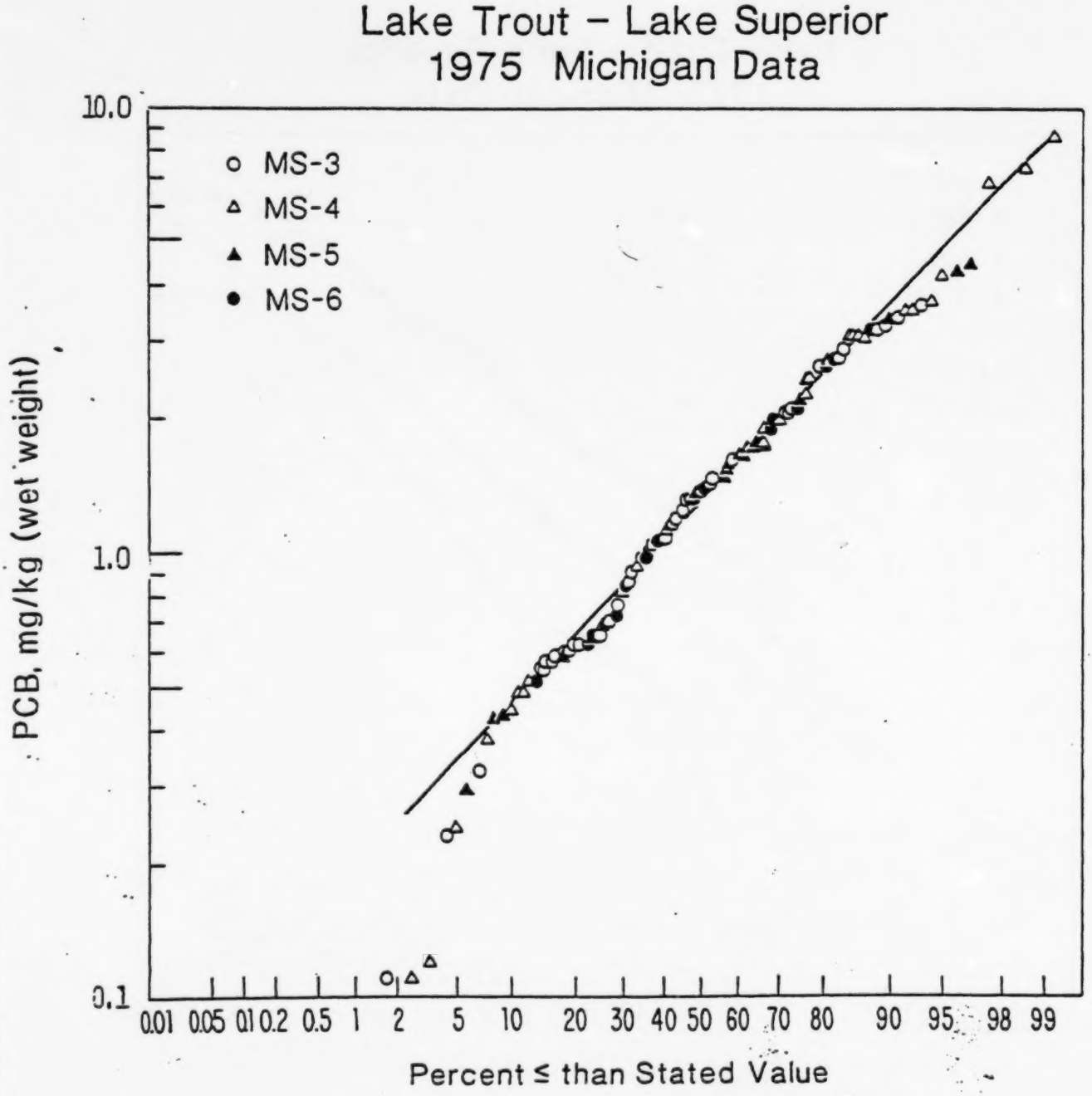
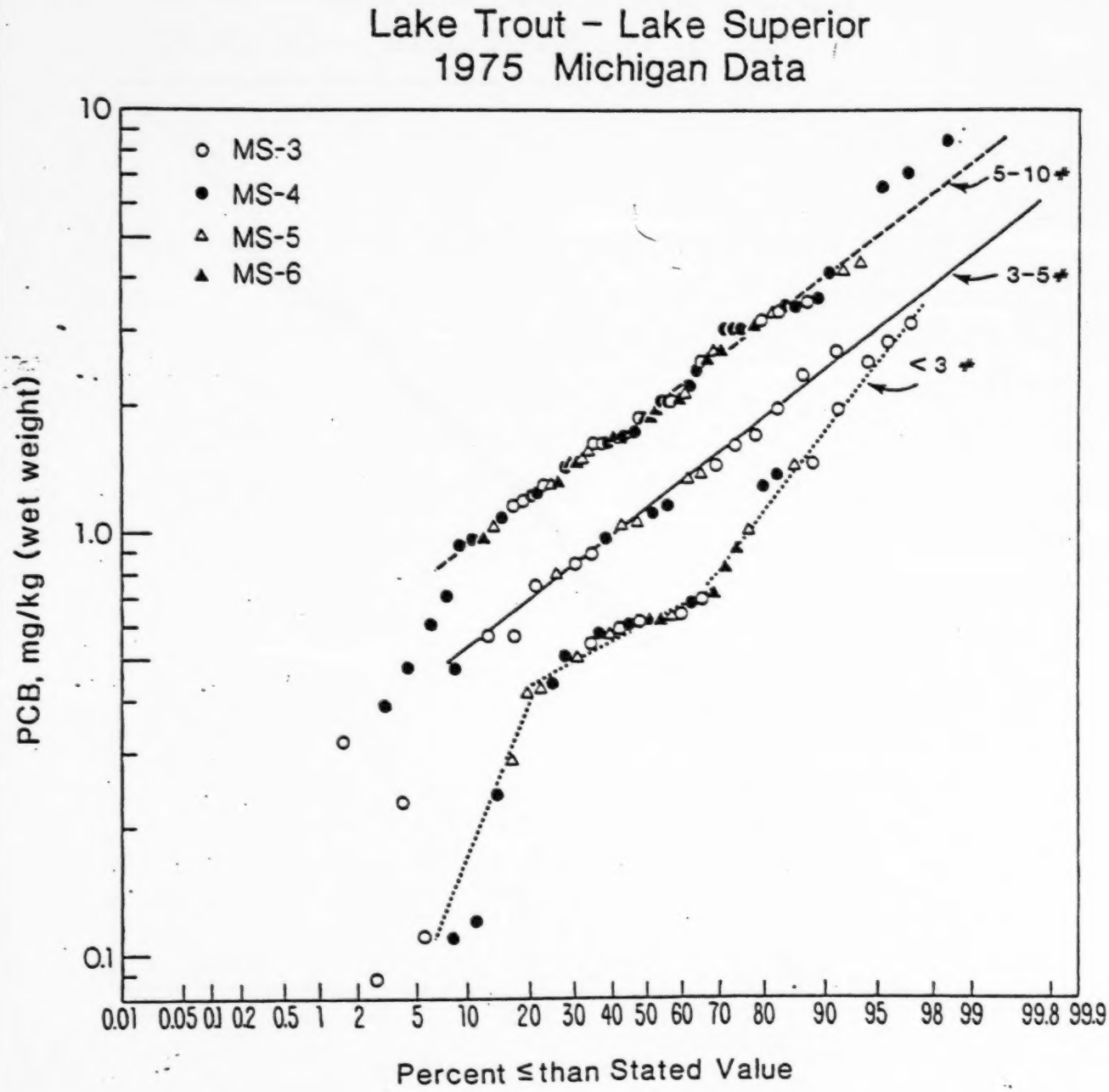

Lake Trout – Lake Superior
1975 Michigan Data
MS-3
MS-4
MS-5
MS-6
10.0
1.0
0.1
PCB, mg/kg (wet weight)
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99
Percent ≤ than Stated Value

Fig. 11


Lake Trout – Lake Superior
1975 Michigan Data
MS-3
MS-4
MS-5
MS-6
5-10#
3-5#
< 3 #
PCB, mg/kg (wet weight)
10
1.0
0.1
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.9
Percent ≤ than Stated Value

$M(g) \overset{x}{\div} \sigma(g)$ = 0.64 $\overset{x}{\div}$ 2.14 mg/kg; for the 3 to 5 lb weight, 1.13 $\overset{x}{\div}$ 1.81 mg/kg; and for the 5 to 10 lb weight 1.94 $\overset{x}{\div}$ 1.80 mg/kg. Further examination of these data shows that approximately 0.35 percent of the less than 3 lb weight fish, less than 0.7 percent of the 3 to 5 lb weight fish, and almost 5.5 percent of the 5 to 10 lb weight fish would exceed the present FDA value of 5 mg/kg PCB in fish. If the value is reduced to 2 mg/kg these values could increase to approximately 7 percent, 17.5 percent, and 49 percent, respectively.

Included here by way of examples are two plots (Figs. 12 and 13) which attempted to ascribe a relation between either length and PCB concentrations or weight and PCB concentrations. It will be seen that a correlation is not readily apparent, however, one can speculate that a possible relationship exists between length and PCB concentration. As can be seen in the logarithmic plot in Fig. 14, the correlation between PCB body burden in mg and weight in grams was much improved. The data used to develop this plot were those reported for the four sampling areas in Lake Superior.

5.1.1. Variation in Lake Trout Correlations by Location.

Reference to Figs. 4a-f show the variation in PCB concentrations with weight and by location. As indicated earlier, lake trout samples taken from Lake Superior designated as MS-3, MS-4, and MS-5, generally showed lower concentrations than did fish taken from point-designated sources. If the assumption is made that the area samples came from open water and the point samples from near-shore locations, the differences might be accounted for by the fact that the fish taken from near-shore areas were exposed to higher concentrations in the bottom muds that were deposited in these areas. Fish taken from the areas indicated might have been exposed to deeper waters and to contributions of PCB primarily from precipitation or dry fallout following uptake through the food chain. Near-shore fish were exposed to higher concentrations in bottom muds contributed form discharges from tributaries receiving surface runoff as well as direct discharge from point sources. Other factors which could effect differences in PCB concentrations would be the food chain of

Fig. 12

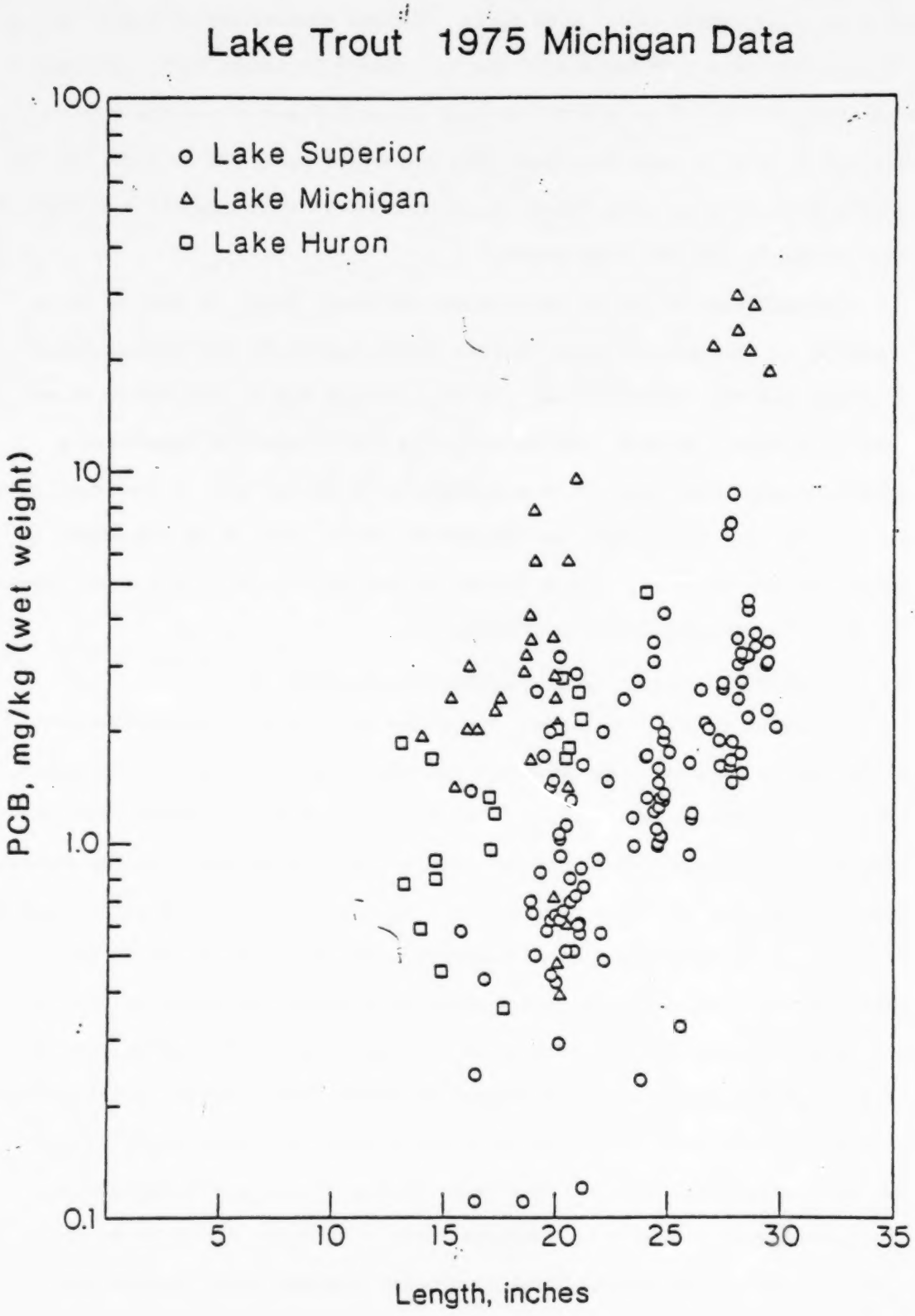

Lake Trout 1975 Michigan Data
Lake Superior
Lake Michigan
Lake Huron
PCB, mg/kg (wet weight)
100
10
1.0
0.1
5
10
15
20
25
30
35
Length, inches

Fig. 13

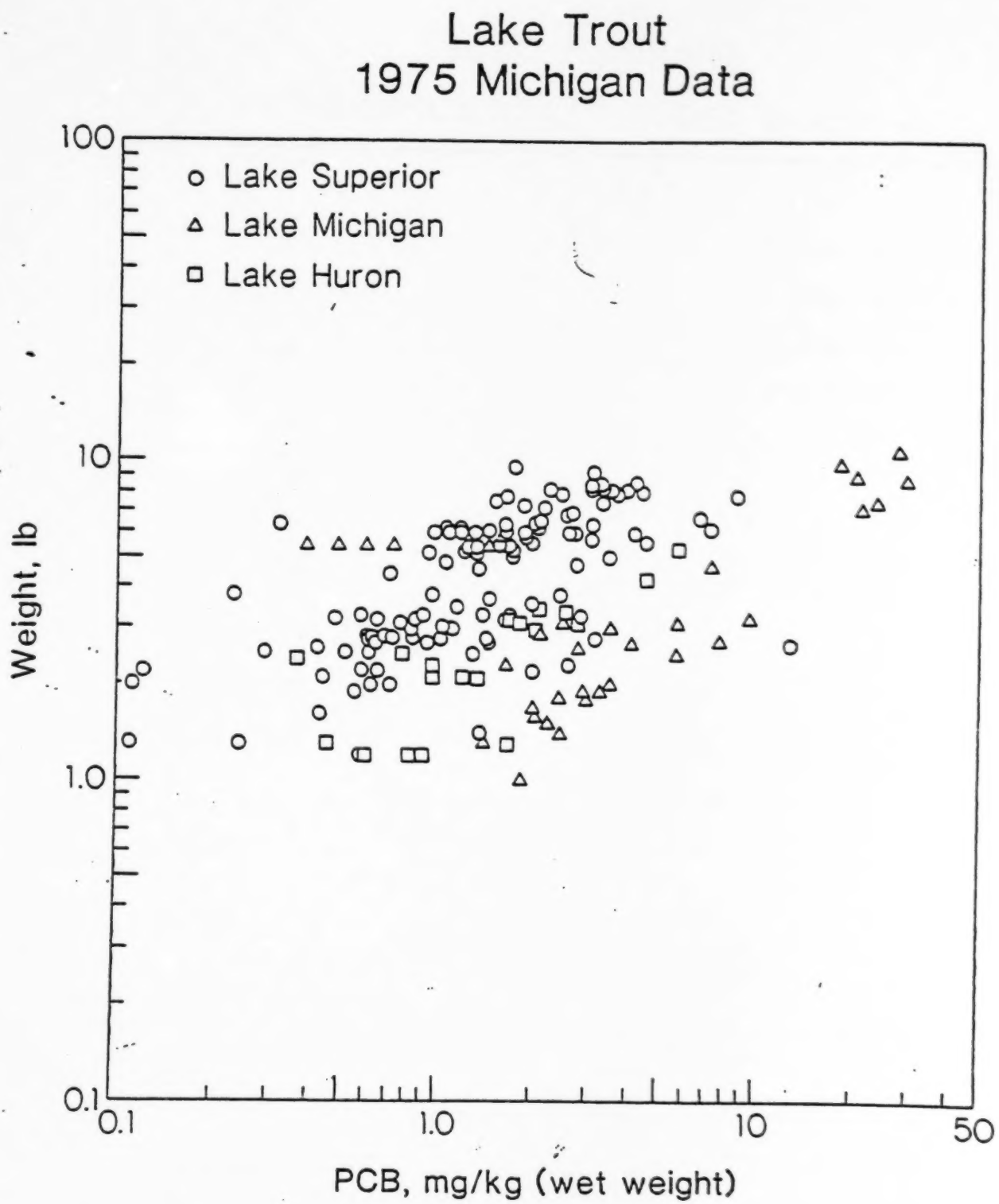
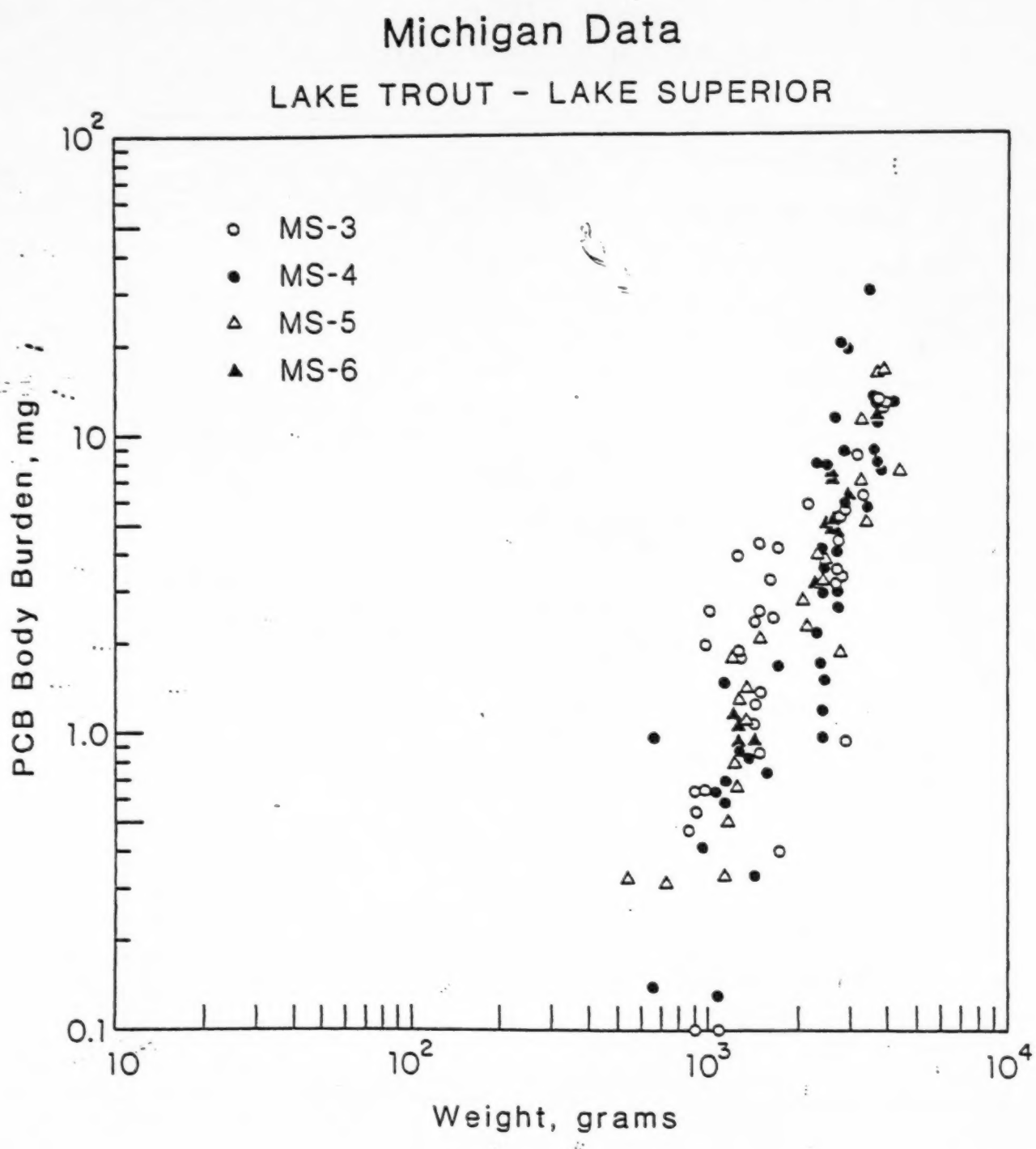

Lake Trout
1975 Michigan Data
Lake Superior
Lake Michigan
Lake Huron
100
10
1.0
0.1
Weight, lb
0.1
1.0
10
50
PCB, mg/kg (wet weight)

Fig. 14


Michigan Data
LAKE TROUT - LAKE SUPERIOR
MS-3
MS-4
MS-5
MS-6
PCB Body Burden, mg
Weight, grams
10^2
10
1.0
0.1
10^2
10^3
10^4

fish caught in deep water versus those taken from near-shore areas. Since information is not given on actual sample locations, the above reasoning is purely speculative.

If the levels reported thus far, primarily 1974 and 1975, but with values as recent as 1977, are still indicative of fish concentrations today, it will be seen from a further examination of Figs. 4a-f that there are a number of areas where fish PCB levels exceed the current FDA limit of 5 mg/kg and if the level is lowered to 2 mg/kg that many more fish would exceed this limit. Areas exceeding the 5 mg/kg level, in terms of median concentrations, include Isle Royale for fish in the 5 to 10 lb weight group; Ontanagon, 3 to 5 lb; Calumet, all weight groupings at different times; Marquette, 3 to 5 lb and 5 to 10 lb; Open water area (MS-5) for all weight groups; Grand Marais, 3 to 5 and 5 to 10 lb; Whitefish Bay, some fish in the 5 to 10 lb group; Escanaba, less than 3 lb; Saugatuck, less than 3 lb and 3 to 5 lb; Sheboygan, 3 to 5 and 5 to 10 lb; and southern Lake Michigan (Indiana data), all weight groupings. The highest levels reported generally were in fish collected in Marquette, Grand Marais, and southern Lake Michigan areas.

Some the above observations are based upon the analysis of very few fish, but with the normal geometric variation indicated for these data, one can expect considerable variation from these single values. These single values certainly cannot be considered as maxima and one would expect higher levels than those reported. There is a need for more information, particularily from those areas which indicate potential for high concentrations in fish.

5.2. Yellow Perch.

The yellow perch was identified as the fish specie most preferred by commercial fishermen. Available concentrations are plotted in Fig. 5 by time and site. All of the data reported, at most one or two samples in each time period at a given site, are for fish under 3 lb weight. A review of Fig. 5 indicates that fish taken at Saugatuck, Sheboygan, and Port Ontario exceed the FDA limit

of 5 mg/kg. From the data indicated and based on the most recent levels found in one or two fish sampled, all of the remaining areas sampled would apparently meet even the proposed 2 mg/kg limit. However, this statement is based on the very few samples collected at a given time or place. It would be of value to determine levels in yellow perch at other locations if they are present in those waters, but most important would be further sample collections to obtain information on the variation in levels that can occur in this species at thsse critical locations, namely, Saugatuck, Sheboygan, and Port Ontario.

5.3. Lake Whitefish.

The second most preferred species of fish identified by commercial fishermen was the lake whitefish. Relatively few data are available as indicated in Fig. 6 and all results reported were below the present FDA level of 5 mg/kg and the proposed level of 2 mg/kg.

5.4. Lake Herring.

This was the fourth most preferred fish as indicated by the commercial fishermen. Little information was available on levels of PCB in this species of fish since only one value was reported from a sample taken at Keweenaw Point on Lake Superior in 1974. The PCB level reported at that time was 1.1 mg/kg for a fish less than 3 lb weight. There is need to obtain more information on this species of fish, not only because it is consumed by man, but because it may be a major factor in the prey-predator ecological system in Lake Superior.

5.5. Other Fish.

A number of other fish were sampled at various locations and at various times. The significance of findings relating to these will be discussed in this section. Fat trout (see Fig. 5) data indicate an increase in concentration as a function of fish weight and location in Lake Superior with the lowest levels recorded in samples collected in the western end of the lake and increasing as one moved eastward. If the levels indicated for 1975 are still valid the median values for the 5 to 10 lb fish from area MS-1, and all other fish taken from

areas MS-3 and MS-5 exceed the current 5 mg/kg FDA limit. All median values indicated would exceed the proposed level of 2 mg/kg.

Some individual levels of walleye (Fig. 6) exceeded the 5 mg/kg FDA limit but where more samples were collected all median values were below 1 mg/kg. Data shown in Fig. 6 for sucker indicated higher levels of PCB present in a sample collected at Sheboygan in 1969 as compared to two samples collected in 1974. In general, all other fish concentrations were in the range of 0.1 to 1.0 mg/kg.

Bloater (Fig. 7) showed high concentrations in samples taken at Saugatuck, Sheboygan, and Beaver Island.

Levels in both brown and rainbow trout were low (Fig. 7).

Salmon levels at Monroe were low for fish less than 3 lb weight. Analysis for chinook salmon collected in lower Lake Michigan showed a reduction in concentration with time for fish greater than 10 lb weight. The average value for two samples collected in 1977 was slightly greater than 5 mg/kg. Fish less than 3 lb weight had concentrations in the 0.01 to 0.4 mg/kg range. Cisco levels at Calumet had a median concentration of 0.85 mg/kg and at Marquette 0.19 mg/kg.

Highest carp concentrations were observed in Lake St. Clair and Lake Erie, but all median or average values were below 5 mg/kg (Fig. 8).

Median catfish concentrations for fish less than 3 lb weight were higher than those indicated for carp, and all were in the range of 5 mg/kg (Fig. 8). Two channel catfish samples averaged less than 5 mg/kg (Fig. 8).

White bass concentrations varied with location, the highest concentration (in excess of 10 mg/kg) was reported for a single sample of fish taken at Port Clinton in 1974 (Fig. 9). Rock bass samples collected only from Port Ontario fluctuated somewhat ranging with time from about 2.5 to 7 mg/kg (Fig. 9). Additional samples are needed to confirm the levels indicated, since several of the samples exceeded the 5 mg/kg FDA limit. Two small mouth bass samples averaged 4.7 mg/kg for fish under 3 lb weight (Fig. 9).

White perch at Port Ontario (Fig. 9) fluctuated from 3.5 to 14.1 mg/kg. With one exception, when two samples were taken, all values are for single samples. In addition, the last value reported in 1974 was the highest value indicated.

Northern pike (Fig. 9) showed lower levels in the Genesee River but higher levels in the St. Lawrence River at Massena: the highest concentration (19.0 mg/kg) was reported for a 3 to 5 lb fish; lower concentrations, ranging from 2.6 to 5.9 mg/kg, were observed for fish less than 3 lb weight.

The three red sucker samples (Fig. 9) collected from the Genesee River were all below 2 mg/kg.

Fresh water drum samples taken from Monroe were below 2 mg/kg in concentration whereas those taken at Erie, Pa. were in the range of 1.1 to 2.6 mg/kg (Fig. 9).

Burbot samples (Table A-2) taken from Lake Michigan were low for fish less than 3 lb and 3 to 5 lb, but a single sample of a 5 to 10 lb fish yielded a PCB concentration of 5.6 mg/kg.

Two samples of muskie taken from the Lake St. Clair averaged 1.5 mg/kg.

A single smelt sample taken in Lake Huron in 1975 showed a concentration of 0.65 mg/kg. It is unfortunate that no more samples were collected of smelt, since they are consumed extensively at particular times of the year, and, in addition, they constitute a major portion of food supply of lake predators. To provide a better understanding of food chain relationships additional analysis should be carried out.

In many cases, the data reported for the various fish species encountered are extremely few, making any valid interpretations extremely difficult, if not impossible. Since fish constitute the major exposure route to man, more information is needed on PCB concentrations in fish, particularly in these areas where higher levels have been observed.

5.6. Specie Differences in PCB Concentrations.

Comparisons can be made of species collected in the same general location

to identify increased concentrations and uptake.

5.6.1. Lake Superior.

Multiple species of fish were collected at Bayfield (lake trout, whitefish, and bloater); at Calumet (lake trout, whitefish, bloater, cisco); at Keweenaw Point (lake trout, lake herring, bloater); MS-3 (lake trout, fat trout); Marquette (lake trout, whitefish, bloater, cisco); and MS-5 (lake trout, fat trout).

At Bayfield the whitefish and bloater sampled were less than 3 lb weight and the concentration in bloater (0.76-3.5 mg/kg) was just a little higher than that for whitefish (0.31 to 2.0 mg/kg), whereas the lake trout sampled were in the 3 to 5 lb class (1.4 to 2.8 mg/kg) and 5 to 10 lb class (1.5 to 2.7 mg/kg).

At Calumet the concentrations of PCB in fish less than 3 lb were lake trout > whitefish = cisco; in the 3 to 5 lb class, lake trout > whitefish > bloater; no whitefish, bloater, or cisco were caught in the 5 to 10 or greater than 10 lb class to compare with lake trout in this weight range.

At Keweenaw Point the lake trout and bloater sampled were in different weight classes and cannot be compared. Bloater and lake herring concentrations were apparently equal for the less than 3 lb weight class.

Fat trout taken from area MS-3 were 30 to 100 times higher in concentration for respective weight sizes compared to lake trout.

At Marquette concentration differences for the less than 3 lb weight were lake trout > whitefish = cisco; for the 3 to 5 lb weight, lake trout > whitefish; and for the 5 to 10 lb weight, lake trout > bloater.

At MS-5, concentrations in fat trout exceeded those reported for lake trout by 227, 262, and 520 times for weights less than 3 lb, 3 to 5 lb, and 5 to 10 lb, respectively.

5.6.2. Lake Michigan.

Multiple species of fish were collected from Lake Michigan at the following points: Escanaba (lake trout, burbot); Saugatuck (lake trout, yellow perch, bloater); Sheboygan (lake trout, yellow perch, sucker, bloater); and lower Lake Michigan (lake trout, yellow perch, chinook salmon).

At Escanaba the lake trout exceeded the concentration for burbot in the less than 3 lb weight class.

At Saugatuck the concentration order was lake trout > yellow perch > bloater, for the less than 3 lb weight class.

At Sheboygan for the less than 3 lb weight class the order was yellow perch = bloater > sucker. Lake trout sampled were all larger than the < 3 lb size.

Fish species collected in lower Lake Michigan showed the following concentration patterns: less than 3 lb weight, lake trout > yellow perch; and greater than 10 lb weight, lake trout > chinook salmon.

5.6.3. Lake Huron.

Several species of fish were collected from each of the following areas on Lake Huron: MH-1 (lake trout, whitefish, sucker, smelt); Alpena (lake trout, yellow perch, whitefish, sucker); and MH-3 (whitefish and chinook salmon).

At MH-1 the order of concentration was lake trout > smelt = sucker > whitefish for fish less than 3 lb weight.

The order for concentration at Alpena for the less than 3 lb group was yellow perch = sucker > whitefish.

At MH-3 the order for both the less than 3 lb and 3 to 5 lb groups was chinook salmon > whitefish.

5.6.4. Lake St. Clair.

Species collected in Lake St. Clair were catfish, yellow perch, white bass, and muskie and at Mt. Clemens along Lake St. Clair, carp, walleye, and white bass.

For Lake St. Clair the order of concentrations was yellow perch > white bass > walleye in the less than 3 lb group, and catfish > walleye for the 3 to 5 lb class; at Mt. Clemens the order was walleye $\geq$ carp > white bass.

5.6.5. Lake Erie.

Species collected at points on Lake Erie included carp, catfish, walleye, white bass, fresh water drum, rainbow trout, salmon, and chinook salmon at

Monroe; carp, walleye, and white bass at Port Clinton; and yellow perch, sucker, and fresh water drum at Erie.

At Monroe, Michigan the order of concentrations found for the less than 3 lb weight size was catfish > carp > white bass > walleye = rainbow trout > salmon > chinook salmon > fresh water drum; at Port Clinton, Ohio the order was white bass > yellow perch > sucker; at Erie, Pennsylvania the order was fresh water drum > sucker > yellow perch.

5.6.6. Lake Ontario.

Sampling locations and species collected from Lake Ontario were Port Ontario (carp, catfish, yellow perch, rock bass, channel catfish, and white perch), and Cape Vincent (yellow perch, brown bullhead).

For Port Ontario the order of PCB concentrations in fish less than 3 lb weight was white perch > yellow perch > catfish = channel catfish > rock bass > carp; and at Cape Vincent the order was brown bullhead > yellow perch.

5.6.7. Genesee River at Scottsville, New York.

Several species of fish were collect at Scottsville and included carp, walleye, sucker, red bass, red sucker, black crappie, and Northern pike. The order of concentration was carp > walleye > sucker > red sucker = Northern pike > black crappie > rock bass for fish under 3 lb weight.

5.6.8. St. Lawrence River, Massena, New York.

Three species of fish were sampled at Massena, namely: yellow perch, small mouth bass, and Northern pike. The order of concentration for fish under 3 lb weight was small mouth bass > Northern pike > yellow perch.

From the specie concentrations indicated above, there are specie differences at different locations. This statement is based on a very limited number of analysis in many instances and may not truly reflect intake considerations. Such information is of general interest in that it identifies those species which have the highest concentrations, reflects on the food chain habits of the fish, and helps identify their ecological niche in Great Lake waters in relation to the

characteristics of these waters. Much more information is needed. Overall, based on areas from which the fish were obtained, it appears that the highest concentrations reported were for lake trout taken from the lower end of Lake Michigan and from the Open water area and Grand Marais in eastern Lake Superior. Similar high values were reported for fat trout taken from the same area of Lake Superior.

6.0. References.

1. Great Lakes Environmental Contamination Survey-1975, Michigan Department of Agriculture in conjunction with Michigan Department of Natural Resources, Michigan Department of Health, Food and Drug Administration.

2. United States Fish and Wildlife Data. STORET EPA KBS 4Y, September 10, 1980.

3. United States Fish and Wildlife Data. STORET EPA KBS 1C, August 20, 1980.

4. Fish Data-Upper Peninsula, Michigan, STORET EPA KBS 19, August 20, 1980.

5. Fish Data-Upper Peninsula, Michigan, STORET EPA KBS 1A, Agusut 20, 1980.

6. Koch, R.A., Contaminant Levels in the Fishes of Southern Lake Michigan, 1973-1978. Fisheries Section, Indiana Department of Natural Resources, Division of Fish and Wildlife, Indianapolis, Indiana 46204 (1979).

TABLE A.1. Summary of Lake Trout Data Examined

Location	Sampling Date	PCB mg/kg (wet wgt.) Md.	Range	No. Analysis	Size, lb
Lake Superior, Bayfield, Wisconsin	1969	2.84		1	3-5
	1970	1.29		1	3-5
	1971	1.41	(1.10-1.72)	2	3-5
	1972	2.15	(1.30-3.00)	2	3-5
	1974	2.7		1	5-10
	1977	1.5		1	5-10
Lake Superior, Isle Royale (MI) MS-1 (Keweenaw County).	May, 1974	0.73	(0.33-5.66)	5	< 3
		1.8	(1.4-2.8)	4	3-5
		3.33	(1.99-5.99)	3	5-10
	May, 1975	3.07	(1.73-3.84)	7	< 3
		4.04	(2.17-7.37)	7	3-5
		6.29	(3.47-13.03)	5	5-10
Lake Superior, Ontonagon (MI)-MS-2 (Ontonagon County)	June, 1974	2.25	(1.60-3.87)	5	< 3
		8.80	(1.11-14.40)	17	3-5
	July, 1974	2.69	(0.43-3.85)	7	< 3
		6.57	(4.18-11.40)	6	3-5
		4.99	(3.57-8.4)	5	5-10
Lake Superior, Calumet (MI) MS-3 (Keweenaw County)	Feb., 1974	6.86	(2.67-18.41)	7	< 3
	May, 1974	0.38	(0.02-0.78)	11	< 3
		0.69	(0.02-2.28)	6	3-5
		1.66	(0.99-6.81)	10	5-10
	June, 1974	1.25	(1.20-1.65)	3	< 3
		2.32	(1.35-10.62)	4	3-5
		2.48	(1.87-4.5)	4	5-10
		3.94		1	> 10
	July, 1974	8.62	(1.5-10.50)	5	3-5
		5.47	(2.75-10.50)	10	5-10
	May, 1975	5.8	(1.42-12.25)	9	< 3
		2.20	(0.57-12.9)	10	3-5
		3.30	(0.32-11.61)	8	5-10

TABLE A.1. Summary of Lake Trout Data Examined (Cont'd)

Location	Sampling Date	PCB mg/kg (wet wgt.) Md.	Range	No. Analysis	Size, lb
Lake Superior, Keweenaw Point (MI) MS-3 (Keweenaw County)	1974	4.5		1	5-10
	1977	0.70		1	3-5
Lake Superior, Betsy Bay (MI) MS-3	May, 1975	0.60	(0.09-0.70)	7	< 3
		0.76	(0.23-0.90)	5	3-5
		1.41	(1.16-2.08)	6	5-10
Lake Superior-MS-3	1975	0.65	(0.09-3.14)	11	< 3
		1.45	(0.23-2.89)	13	3-5
		1.74	(0.32-3.54)	12	5-10
Lake Superior, Marquette (MI) MS-4 (Marquette County)	Feb., 1974	10.52	(7.89-15.78)	4	< 3
	May, 1974	0.66	(0.02-1.32)	15	< 3
		0.99	(0.52-1.45)	2	3-5
		1.98	(0.46-4.47)	10	5-10
	June, 1974	3.33	(1.96-5.55)	7	< 3
		2.80	(0.93-6.40)	8	3-5
		3.44	(0.15-13.5)	27	5-10
		13.5		1	> 10
	Oct., 1974	0.95	(0.42-1.32)	9	3-5
		1.85	(1.02-24.0)	15	3-10
		5.29	(3.77-18.75)	5	> 10
	May, 1975	0.48	(0.12-0.61)	4	< 3
		0.84	(0.48-1.16)	2	3-5
		6.20	(0.93-7.2)	3	5-10
Lake Superior, Grand Portal (MI) MS-4 (Alger County)	June, 1975	1.00	(0.11-1.38)	4	< 3
		1.08	(1.04-1.11)	2	3-5
		3.11	(1.73-8.61)	9	5-10
Lake Superior, MS-4	1975	0.54	(0.11-1.38)	10	< 3
		1.04	(0.48-1.16)	4	3-5
		2.04	(0.39-8.60)	28	5-10
Lake Superior, Au Sable (MI) MS-5 (Alger County)	May, 1975	0.51	(0.29-1.46)	7	< 3
		1.20	(1.05-1.34)	2	3-5
		1.72	(1.02-4.2)	9	5-10

TABLE A.1. Summary of Lake Trout Data Examined (Cont'd)

Location	Sampling Date	PCB mg/kg (wet wgt.) Md.	Range	No. Analysis	Size, lb
Lake Superior, Open Waters (MI) MS-5	June, 1975	14.84	(4.68-45.15)	6	<3
		17.07	(14.06-36.58)	6	3-5
		27.19	(24.39-29.26)	4	5-10
		10.36	(4.03-31.25)	4	>10
Lake Superior, Grand Marais (MI) MS-5 (Alger County)	May, 1975	1.12	(0.96-2.56)	5	<3
		1.33	(0.64-1.44)	3	3-5
		1.52	(1.12-2.40)	6	5-10
	Sept., 1975	36.76	(29.56-43.97)	2	3-5
		39.58	(17.69-61.56)	2	5-10
Lake Superior, MS-5	1975	0.54	(0.29-1.48)	8	<3
		1.05	(0.81-1.39)	5	3-5
		1.72	(1.02-4.42)	11	5-10
Lake Superior, Whitefish Bay (MI) MS-6 (Chippewa County)	May, 1974	0.38	(0.29-0.51)	5	<3
		0.81	(0.51-3.22)	3	3-5
		1.18	(0.74-1.75)	5	5-10
	June, 1974	1.94	(0.59-3.33)	6	3-5
		5.18	(3.60-5.92)	4	5-10
	May-June, 1975	0.72	(0.62-0.92)	5	<3
		0.65		1	3-5
		1.87	(0.97-3.12)	12	5-10
Lake Superior, MS-6	1975	0.72	(0.62-0.92)	5	<3
		0.65		1	3-5
		1.87	(0.97-3.12)	12	5-10
Lake Michigan, Escanaba (MI) MM-1 (Delta County)	Jan., 1974	1.10	(0.74-2.03)	3	<3
	Dec., 1975	2.67	(1.40-3.50)	6	<3
Lake Michigan, MM-1	1975	2.67	(1.40-3.50)	6	<3
Lake Michigan, MM-3 (Beaver Island, MI) (Charlevoix County)	1977	1.6		1	5-10

TABLE A.1. Summary of Lake Trout Data Examined (Cont'd)

Location	Sampling Date	PCB mg/kg (Wet wgt.) Md.	Range	No. Analysis	Size, lb*
Lake Michigan, MM-5	1975	2.10	(1.66-5.66)	7	< 3
		4.19	(2.64-5.74)	2	3-5
		23.6	(21.50-29.43)	3	5-10
Lake Michigan, MM-6	1975	2.61	(2.25-7.82)	4	< 3
		6.56	(3.56-9.55)	2	3-5
		23.54	(18.24-28.85)	2	5-10
		27.8		1	> 10
Lake Michigan, Saugatuck, (MI) MM-8, (Allegan County)	1974	13.0		1	< 3
	1977	7.3		1	3-5
Lake Michigan, Sheboygan (WI) (Sheboygan County)	1971	7.81	(7.03-8.59)	2	5-10
	1973	9.8	(7.9-11.7)	2	3-5
	1974	0.6		1	3-5
	1977	6.9		1	3-5
		13.6		1	5-10
Lake Michigan, Lower end (Indiana)	1974	44	(31-60)	4	5-10
		37		1	> 10
	1975	8.6	(7.9-13.7)	6	3-5 +
		12.4	(7.9-21.8)	6	5-10+
		10		1	> 10+
	May-June, 1976	1.5	(0.86-3.4)	5	< 3 +
		2.7	(1.0-3.0)	3	3-5 +
		5.3	(1.3-11.2)	8	5-10+
		19.6		1	> 10+
	Oct., 1976	11.5	(4.42-29.4)	4	3-5 +#
		55.2	(7.71-122.0)	15	5-10+#
		71.8	(66.1-93.3)	4	> 10+#
	April, 1977	6.44		1	< 3 +
		5.02	(3.8-7.36)	4	3-5 +
		11.0	(6.08-36.2)	6	5-10+
		19.9		1	> 10+
Lake Huron, MH-1	1975	0.93	(0.36-1.85)	12	< 3
		2.10	(1.65-2.76)	6	3-5
Lake Huron, Alpena (MI) MH-2 (Alpena County)	1977	4.6		1	3-5
Lake Huron, MH-5	1975	5.7		1	5-10

*Sample analyzed generally included 3 fish.
+Weight estimated from length.
#Fin clips.

TABLE A.2. Summary of Other Fish Data Examined

Fish Species	Location	Sampling Date	PCB mg/kg Md.	Range	Analysis	Size lb
Sucker	Lake Michigan-Sheboygan, WI	1969	14.80		1	< 3
		1974	1.85	(1.70-2.00)	2	< 3
	Lake Huron MH-1	1975	0.63	(0.48-0.87)	6	< 3
	Lake Huron-Alpena MH-2	1974	0.46		1	< 3
		1977	0.80	(0.60-1.10)	3	< 3
	Lake Erie, Erie, PA	1969	2.48		1	< 3
		1970	2.08		1	< 3
		1971	1.30	(1.19-1.42)	2	< 3
		1972	2.20		1	< 3
		1974	0.35		1	< 3
		1977	0.45	(0.40-0.50)	2	< 3
	Genesee River-Scottsville, NY	1969	1.54		1	< 3
		1970	1.56		1	< 3
		1971	1.25	(0.99-1.51)	2	< 3
		1973	2.20		1	< 3
Fat Trout	Lake Superior-MS-1	1975	3.07	(1.73-3.84)	7	< 3
			4.04	(2.17-7.37)	7	3-5
			6.29	(3.47-13.03)	5	5-10
	MS-3	1975	8.38	(5.80-12.25)	5	< 3
			11.28	(9.67-12.9)	2	3-5
			7.74	(3.87-11.61)	2	5-10
	MS-5	1975	14.84	(4.68-45.15)	6	< 3
			23.32	(14.06-43.97)	8	3-5
			27.19	(17.59-61.56)	6	5-10
			20.36	(4.03-31.25)	4	> 10
Carp	Lake Huron MH-4	1975	1.00	(0.50-1.30)	3	3-5
			1.80	(1.40-2.90)	5	5-10
	MH-5	1975	0.40	(0.20-1.20)	6	< 3
			1.20	(0.60-3.20)	4	3-5
			2.75	(0.60-4.90)	2	5-10
	Lake St. Clair-Mt. Clemens	1974	4.1	(1.90-6.30)	2	< 3
		1977	5.7		1	< 3
			4.2		1	3-5
	Lake Erie-Monroe, MI	1975	2.40	(1.00-4.70)	5	< 3
			2.80	(1.00-6.5)	6	3-5
			3.90		1	5-10
	Lake Erie-Port Clinton, OH	1974	1.3		1	< 3
			2.8	(2.4-3.1)	2	< 3
	Genesee River-Scottsville, NY	1977	2.5	(2.3-2.7)	2	< 3
	Lake Ontario, Port Ontario, NY	1970	1.01		1	< 3
Catfish	Lake St. Clair	1975	7.70		1	3-5
			6.05	(5.30-6.80)	2	5-10
	Lake Erie, Monroe, MI	1975	4.75	(0.36-6.50)	6	< 3
	Lake Ontario-Port Ontario, NY	1977	4.9	(4.4-5.4)	2	< 3

TABLE A.2. Summary of Other Fish Examined (Cont'd)

Fish Species	Location	Sampling Date	PCB mg/kg Md.	Range	Analysis	Size lb
Yellow Perch	Lower Lake Michigan, IN*	1973	2.4		1*	< 3
		1971	0.20	(0.11-0.30)	2*	< 3
		1975	0.48	(0.48-1.9)	2*	< 3
	Lake Michigan-Saugatuck MM-8	1974	3.07	(1.73-3.84)	7	< 3
	Lake Michigan-Sheboygan, WI	1969	12.6		1	< 3
		1970	7.42		1	< 3
		1971	11.4	(10.7-12.2)	2	< 3
		1972	9.4	(8.9-9.8)	2	< 3
		1973	7.8	(7.6-8.1)	2	< 3
	Lake Huron-Alpena MH-2	1974	0.69	(0.65-0.73)	2	< 3
	Lake St. Clair	1975	1.20	(1.10-1.30)	2	< 3
	Lake Erie, Erie, PA	1969	2.33		1	< 3
		1970	2.40	(2.34-2.45)	2	< 3
		1971	1.11	(1.00-1.22)	2	< 3
		1972	1.65	(1.5-1.8)	2	< 3
		1973	0.75	(0.70-0.80)	2	< 3
		1974	0.95	(0.90-1.00)	2	< 3
		1977	0.60		1	< 3
	Lake Ontario-Port Ontario, NY	1969	7.08		1	< 3
		1970	2.48	(2.24-2.71)	2	< 3
		1971	7.36	(6.51-8.21)	2	< 3
		1972	6.2	(3.7-8.7)	2	< 3
		1973	5.2	(2.8-7.6)	2	< 3
		1974	7.2	(6.3-8.0)	2	< 3
	Lake Ontario-Cape Vincent, NY	1974	1.1	(0.9-1.3)	2	< 3
	St. Lawrence R.-Massena, NY	1970	1.45	(1.45-1.45)	2	< 3
		1971	2.12	(1.64-2.60)	2	< 3
		1972	3.15	(2.6-3.7)	2	< 3
		1973	1.10	(1.00-1.20)	2	< 3
		1974	1.05	(1.0-1.1)	2	< 3
Whitefish	Lake Superior-Bayfield, WI	1969	1.96		1	< 3
		1970	0.58	(0.55-0.60)	2	< 3
		1971	0.31	(0.24-0.38)	2	< 3
		1974	0.70		1	< 3
		1977	0.60		1	< 3
	Lake Superior-Calumet, MI MS-3	1974	0.83	(0.14-1.3)	3	< 3
			1.12	(0.27-1.96)	3	3-5
	Lake Superior-Marquette, MI MS-4					
		1974	0.22		1	< 3
			0.28	(0.16-0.43)	4	3-5
			0.38	(0.36-0.39)	2	5-10
	Lake Huron, MH-1	1975	0.22	(0.14-0.28)	6	< 3
	Lake Huron, Alpena MH-2	1974	0.51		1	< 3
	Lake Huron, MH-3	1975	0.38	(0.23-0.66)	5	< 3
			0.33	(0.28-0.38)	3	3-5
Walleye	Lake St. Clair, Mt. Clemens	1974	12.00		1	< 3
		1977	5.7		1	< 3
	Lake St. Clair	1975	0.50	(0.30-1.20)	4	< 3
			0.85	(0.01-8.40)	8	3-5

*Variable numbers of fish per sample.

TABLE A.2. Summary of Other Fish Examined (Cont'd)

Fish Species	Location	Sampling Date	PCB mg/kg Md.	Range	Analysis	Size lb
Walleye	Lake Erie, Monroe	1975	0.70	(0.20-1.10)	6	<3
	Lake Erie, Port Clinton	1974	5.7		1	<3
		1977	1.5		1	<3
	Genesee River, Scottsville, NY	1969	1.25		1	<3
		1971	1.04		1	<3
			3.28		1	3-5
		1973	2.55	(2.1-3.0)	2	<3
Red Sucker	Genesee River, NY	1970	1.8•		1	<3
		1972	1.4		1	<3
		1974	0.42		1	<3
Black Crappie	Genesee River, NY	1974	0.88	(0.57-1.20)	2	<3
Brown Bullhead	Cape Vincent, Lake Ontario	1974	3.2		1	<3
Herring	Lake Superior, Keweenaw Pt. MS-3					
		1974	1.1		1	<3
Fresh Water Drum	Lake Erie, Monroe, MI	1975	0.01	(0.01-1.20)	9	<3
	Lake Erie, Erie, PA	1969	1.94		1	<3
		1970	2.60		1	<3
		1971	1.14	(0.73-1.54)	2	<3
		1972	2.6		1	<3
		1974	1.8		1	<3
Bloater	Lake Superior, Bayfield, WI	1969	3.47		1	<3
		1970	0.89		1	<3
		1971	0.76	(0.68-0.83)	2	<3
		1974	2.0	(1.2-2.7)	2	<3
	Lake Superior, Calumet, MI MS-3	1974	0.52	(0.45-1.05)	5	3-5
	Lake Superior, Keweenaw Pt., MI MS-3	1974	0.70	(0.61-0.79)	2	<3
		1977	1.15	(0.90-1.4)	2	<3
	Lake Superior, Marquette, MI MS-4	1974	0.60	(0.44-1.06)	6	5-10
	Lake Michigan-Saugatuck, MI MH-8	1974	4.2		2	<3
		1977	3.2	(3.1-3.3)	2	<3
	Lake Michigan, Sheboygan, WI	1969	12.4		1	<3
		1970	4.36	(3.91-4.82)	2	<3
		1971	2.44	(2.08-2.81)	2	<3
		1973	12.3	(10.9-13.7)	2	<3
		1974	5.4	(3.2-7.6)	2	<3
		1977	2.4	(2.2-2.6)	2	<3
	Lake Michigan, Beaver IS. MM-3	1977	6.8		1	<3
Burbot	Lake Michigan-MM-1 Escanaba, MI	1975	0.24	(0.07-0.81)	6	<3
		1974	0.23	(0.02-0.44)	2	3-5
			5.60		1	5-10

TABLE A.2. Summary of Other Fish Examined (Cont'd)

Fish Species	Location	Sampling Date	PCB mg/kg Md.	PCB mg/kg Range	Number Analysis	Size lb
Brown Trout	Lake Huron-MH-2	1975	0.64	(0.48-0.81)	3	<3
			1.70	(1.13-2.26)	2	3-5
			1.14		1	5-10
Rainbow Trout	Lake Erie, Monroe, MI	1975	0.70		1	<3
Muskie	St. Clair	1975	1.50	(0.01-3.00)	2	>10
Salmon	Lake Erie, Monroe, MI	1975	0.50	(0.01-1.00)	2	>10
Chinook Salmon	Lower Lake Michigan, IN	1973	12.4		1	>10
		1974	12.3	(12.3-12.3)	2	>10
		1975	8.8		1	5-10
		1977	5.16	(2.57-7.75)	2	>10
	Lake Huron, MH-3	1975	1.32	(0.99-1.52)	4	<3
			0.77	(0.71-0.83)	2	3-5
			2.97		1	5-10
	Lake Erie, Monroe, MI	1975	0.40	(0.01-0.40)	5	<3
Cisco	Lake Superior, Calumet, MI MS-3	1974	0.85	(0.48-2.05)	6	<3
	Lake Superior, Marquette, MI MS-4	1974	0.19	(0.13-0.34)	3	<3
Smelt	Lake Huron-MH-1	1975	0.65		1	<3
White Bass	Lake St. Clair	1975	0.60	(0.01-1.10)	5	<3
	Lake St. Clair, Mt. Clemens	1974	3.1		1	<3
	Monroe, Lake Erie, MI	1975	1.8	(0.50-3.30)	7	<3
	Lake Erie, Pt. Clinton, OH	1974	12.0		1	<3
Rock Bass	Genesee River	1969	0.39		1	<3
		1970	1.54		1	<3
		1971	0.55	(0.50-0.60)	2	<3
		1973	0.28		1	<3
	Port Ontario, Lake Ontario	1969	4.1		1	<3
		1970	2.6		1	<3
		1971	4.3	(4.17-4.43)	2	<3
		1972	5.9		1	<3
		1973	2.6		1	<3
		1974	7.0		1	<3
		1977	3.0		1	<3
Small Mouth Bass	St. Lawrence River, Massena, NY	1971	4.70	(3.31-6.09)	2	<3
Channel Catfish	Lake Ontario, Pt. Ontario, NY	1977	4.9	(4.4-5.4)	2	<3
White Perch	Lake Ontario, Pt. Ontario, NY	1969	7.68		1	<3
		1970	4.69		1	<3
		1971	9.76	(8.33-11.2)	2	<3

TABLE A.2. Summary of Other Fish Examined (Cont'd)

Fish Species	Location	Sampling Date	PCB mg/kg Md.	Range	Analysis	Size lb
White Perch	Lake Ontario, Pt. Ontario, NY	1972	5.6		1	<3
		1973	3.5		1	<3
		1974	14.1		1	<3
Northern Pike	Genesee River, NY	1970	0.85		1	<3
		1972	1.8		1	<3
		1974	0.98		1	<3
	St. Lawrence River, Massena	1970	5.94		1	<3
		1972	2.6		1	<3
			19.0		1	3-5
		1973	2.6		1	<3
		1974	3.6		1	<3

APPENDIX B

LAKE SUPERIOR

Length–Weight Relationships – Lake Trout